the glass industry

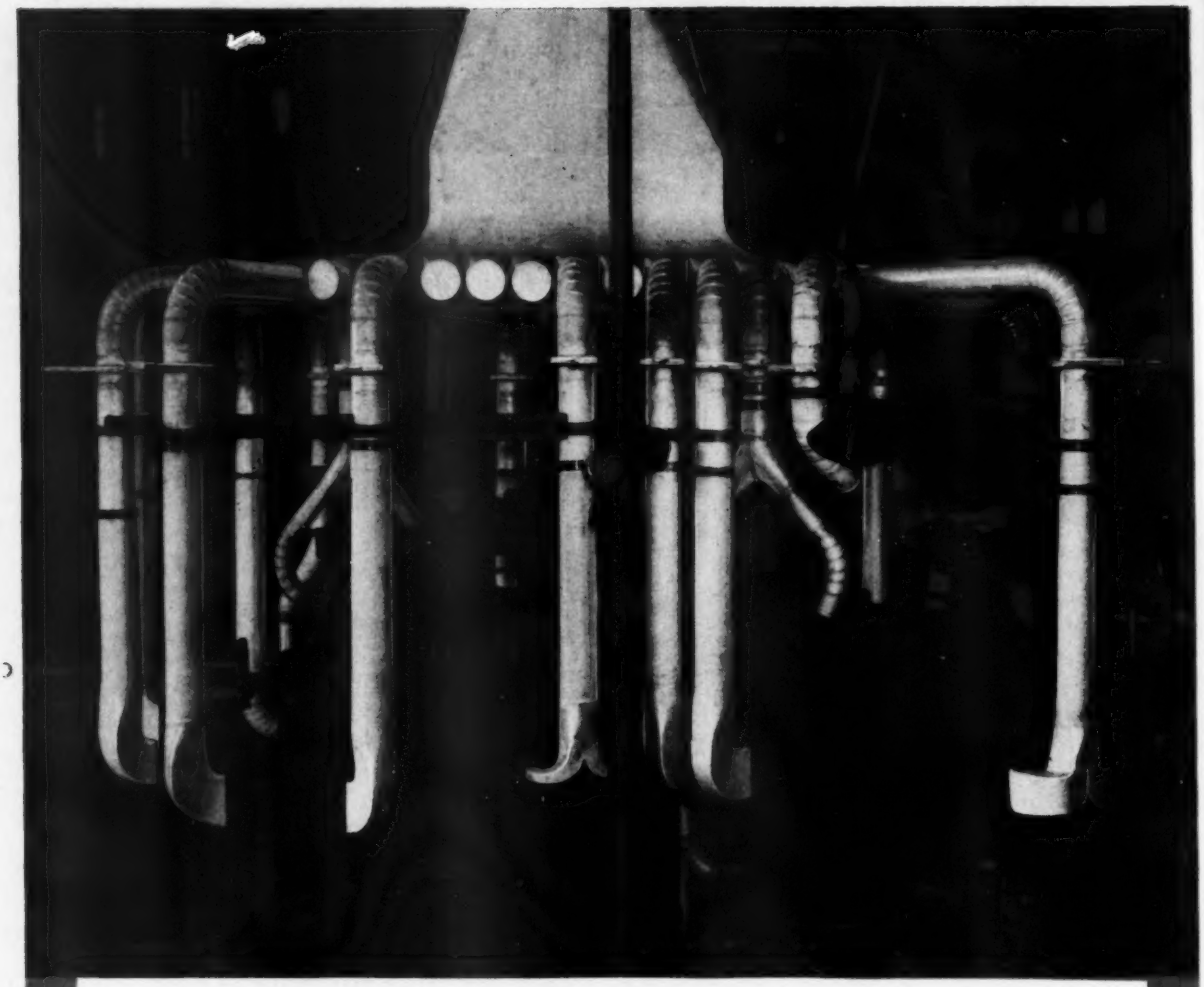

Illustration shows K & B wind system blowing cool air on the new No. 10 Lynch Bottle Machine

THE CHOICE OF LEADING GLASS PLANTS

K & B Engineers have made an exhaustive study of the proper application of wind systems for mould, conveyor and man cooling on the Lynch No. 10 and other types of bottle and Ware machines, and have developed a standard head for most of them. Why not take advantage of this experience and knowledge by requesting us to make a survey of your plant, just as we have done for the following: Ball Bros., Hazel-Atlas Glass Co., Owens-Illinois Glass Co., General Glass Co., Knox Glass Bottle Co., Fourco Glass Co., Chattanooga Glass Bottle Co., Federal Glass Co., Maryland Glass Co., Buck Glass Co.

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Blower Systems

SIMPLEX DRYER
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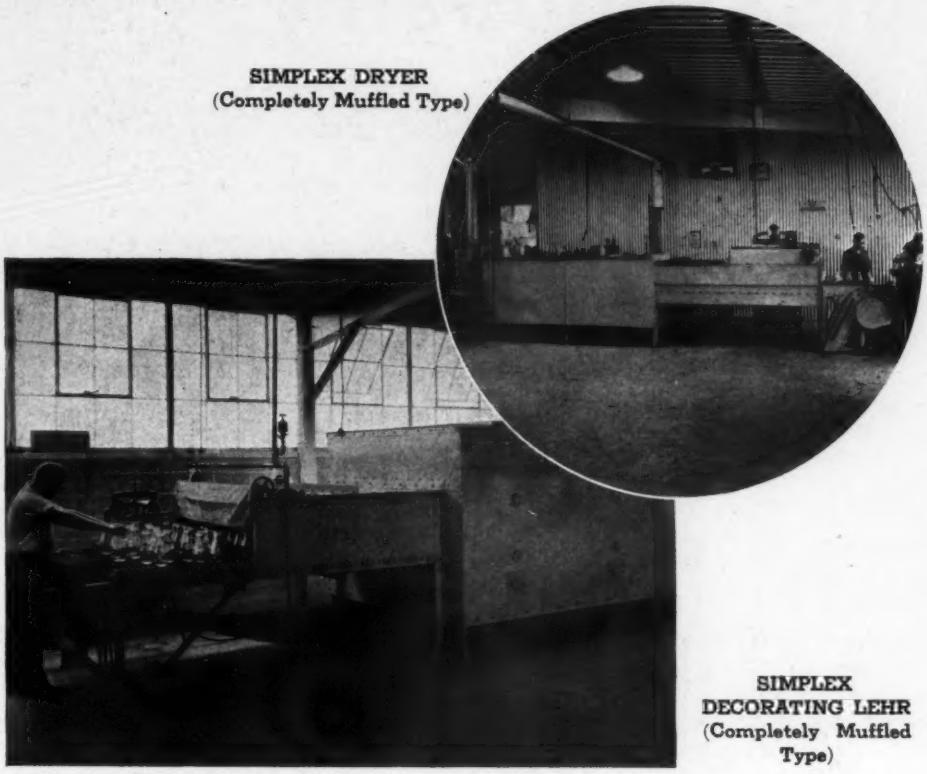

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the glass industry

Devoted to glass technology, engineering, material and glass factory equipment and operation

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Recent Air View of Barberton Plant, THE COLUMBIA ALKALI CORPORATION

Through The Centuries With Alkalies...

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IN this concluding chapter of a series tracing the part which alkalies have played through the ages in the development of many industries, it seems fitting to picture the present Barberton plant of THE COLUMBIA ALKALI CORPORATION as an example of current achievement in alkali production. Here modern science has made possible the manufacture of Soda Ash, Caustic Soda, Sodium Bicarbonate, Modified Sodas, Liquid Chlorine and Calcium Chloride in quantities and quality undreamed of a few decades ago.

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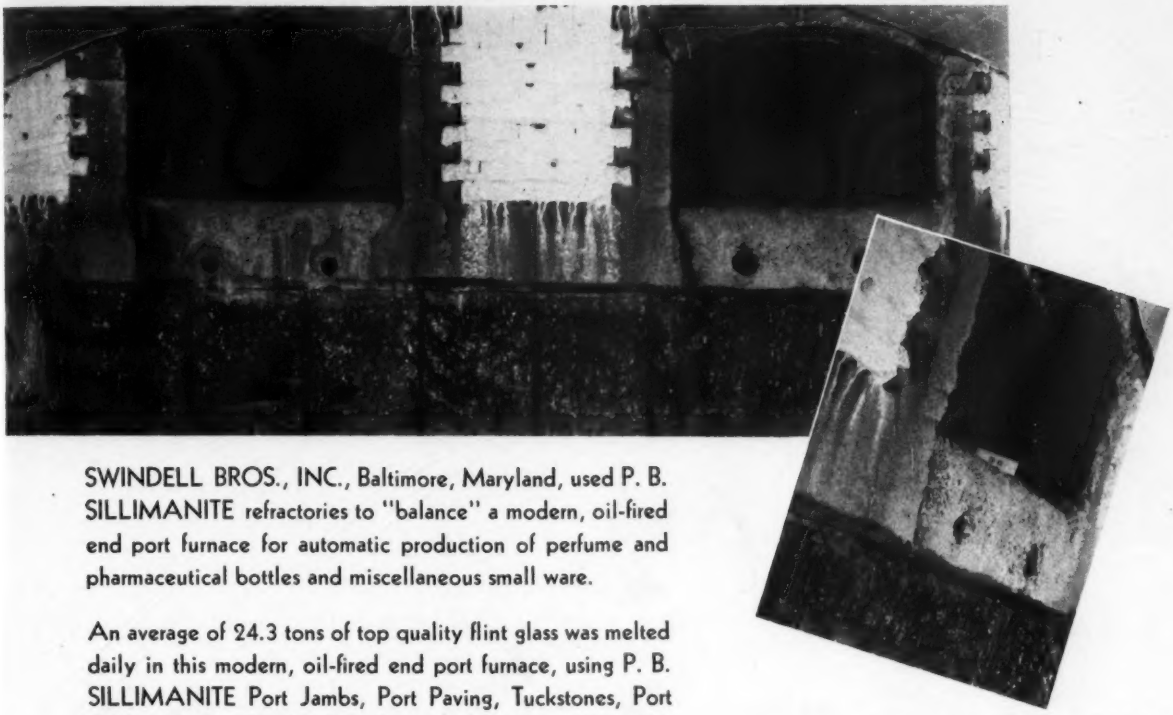
"BALANCE" YOUR TANK WITH P. B. SILLIMANITE AT CRITICAL SPOTS



Candid "shot" of P. B. SILLIMANITE Port. Note the absence of shrinkage, deformation, spalling, washing or dripping, and the marked resistance to attack from batch dust. Burner Blocks retain their original design and provide for proper control of the fire. Tuckstones and Port Sills extend four to six inches beyond flux blocks and protect top of block.

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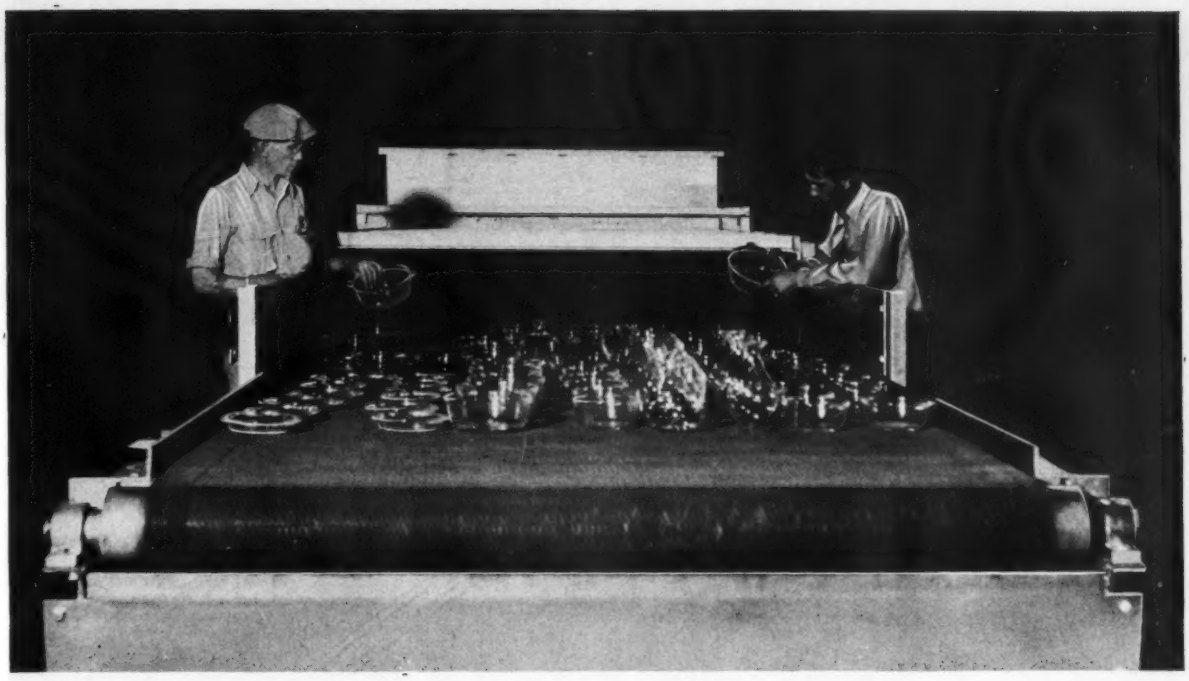

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CAMBRIDGE Duplex Selvage BELT

for Dunbar's New Type Lehr

AS reported in the November issue of *The Glass Industry*, one of the greatest steps forward in the annealing of heat-resisting wear was recently achieved by the Toledo Engineering Co., Inc. for the Dunbar Glass Corporation, Dunbar, West Virginia. Our company is proud of the fact that our Duplex Selvage Belt, 6 feet wide, was chosen as the conveyor in this unusual installation called "Firoll."

The specific feature of this new lehr that makes it different from all other types is that it makes possible, for the first time, annealing of heat-resisting wear at a commercial rate. The necessary uniform high temperature over the entire width is achieved by burning the fuel inside the lehr belt rollers. Heat can be automatically controlled. The exhaust pipe, heavily insulated, prevents any personal injury. In actual operation in the Firoll equipment, the Cambridge Duplex Selvage Belt has satisfactorily withstood the continued high temperature, has proved very efficient.

Cambridge Duplex Selvage Belts are available in practically any size mesh opening, and can be woven to almost any gauge required. Many plants throughout the country have found it wise to consult our engineers for analysis and recommendations on their lehr installations. A Cambridge representative is instantly available to you. Write today to Cambridge Wire Cloth Company, Sunset Boulevard, Cambridge, Maryland.

Cambridge Duplex Selvage provides extra strength at the selvage where most belt troubles start. It helps cut upkeep costs, protects profits by providing dependable, continuous operation.

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assures quality and economy

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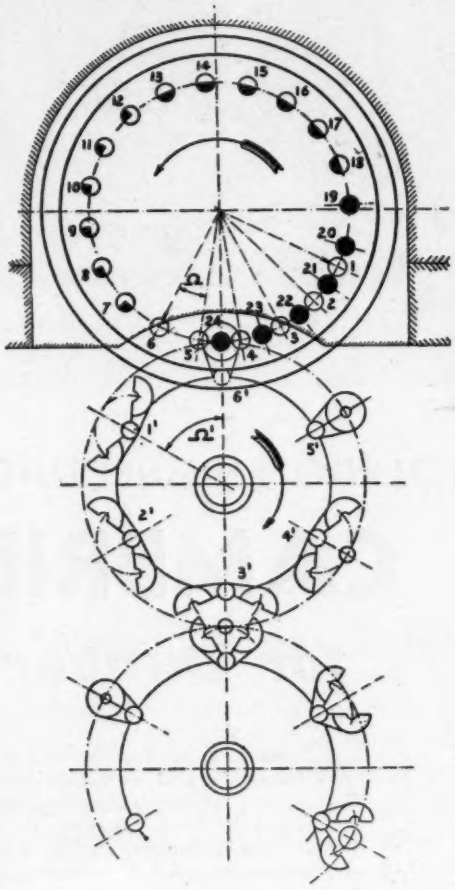
1. Glass surface and parison mould are immobile at moment of suction—insuring greater homogeneity of glass.
2. Due to immobility of machine and revolving pot diameter of the latter is independent of suction time—hence pot diameter has been considerably reduced.
3. This reduction in pot diameter makes possible installation of the revolving pot within the melting tank. The metal therefore is continuously exposed to the regular and most suitable working temperature of the refining tank—the desirable condition of the glass normally destroyed through repeated suctions is re-established at constant intervals. (See illustration).
4. Utilizing the melting tank heat volume to maintain the working temperature assures important savings in fuel consumption. Inclusion of revolving pot in the tank eliminates complicated installation costs.
5. Highest efficiency in maintaining working temperature of glass in pot is obtained through control of relative speed ratios of combined machine and revolving pot. The latter makes only a small fraction of rotation to each complete revolution of the parison mould table.



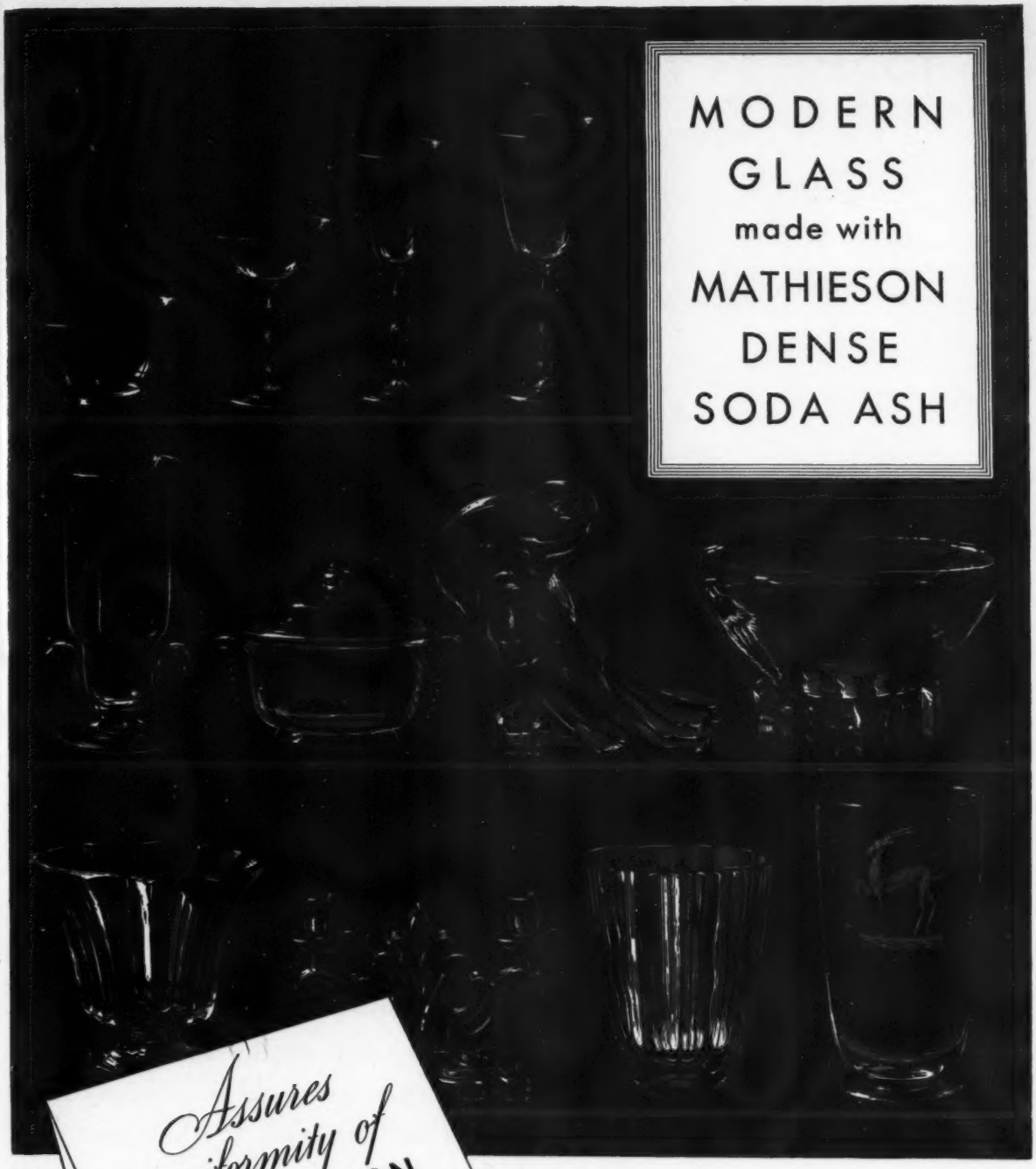
Position of the 4 × 6 = 24 drawing spots 1 to 24 in the revolving pot after four complete revolutions of the parison mould table

- ○ suction spots 1 to 6 – first revolution of the parison mould table 2
- ◔ suction spots 7 to 12 – second revolution of the parison mould table 2
- ◒ suction spots 13 to 18 – third revolution of the parison mould table 2
- ● suction spots 19 to 24 – fourth revolution of the parison mould table 2

etc.

SOCIÉTÉ CONTINENTALE D'APPAREILS MÉCANIQUES POUR LA VERRERIE S. A.

BASEL, SWITZERLAND



MANUFACTURERS of fine modern glass are enthusiastic about the superior quality of Mathieson Dense Soda Ash. ¶ They like it because Mathieson Dense Soda Ash is made especially to fit their needs . . . because its uniform, granular character helps in securing quick, efficient melting and assures uniformity in the finished product . . . because it is free from oversized particles, impurities, dust or foreign matter that might affect quality. ¶ Let us quote on your requirements.

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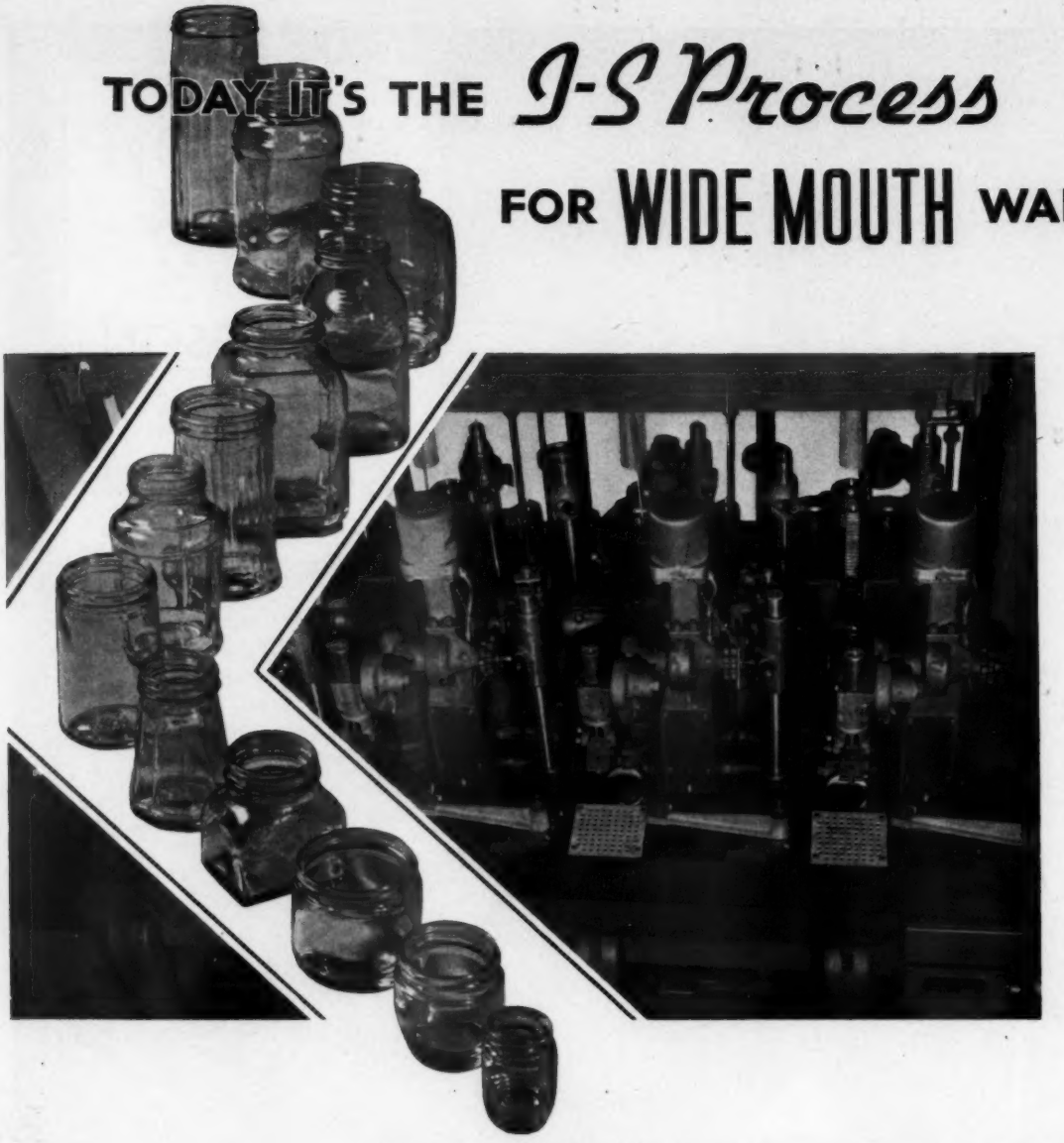
60 EAST 42nd STREET, NEW YORK, N. Y.

TODAY IT'S THE *I-S Process* FOR WIDE MOUTH WARE



The I-S Machine offers exceptional range on WIDE MOUTH ware, with quality and distribution excellent . . . *Production per mold is unusually high.* . . . Our engineers will be glad to show you how the well known exclusive advantages of this process can be applied to your jars as well as to your bottles.

All ware shown in this advertisement was made by this up-to-date method.

HARTFORD EMPIRE COMPANY
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THE GLASS INDUSTRY

VOLUME 20, NUMBER 1, JANUARY, 1939

THE GLASS MONOPOLY HEARINGS

A report of the anti-monopoly investigation made by the T.N.E.C. The Glass Industry believes this to be the only account published of this all-absorbing event wherein the vast amount of disconnected testimony has been so organized as to give the reader an authentic and coherent picture of the situations disclosed by the evidence.

The investigation of the glass container industry conducted by the Temporary National Economic Committee at Washington, D. C., was probably the most important event in the contemporary history of the industry. The hearings were held in the Old Caucus Room of the Senate Office Building. Beginning Monday, Dec. 12th, they continued through Friday, and throughout all of that five-day period individuals and corporations who have been most instrumental in shaping the destinies of bottle manufacturing for the past twenty years were present at one time or another. Some 43 machinery manufacturers, glassmen, engineers and attorneys had been subpoenaed, though not all were actually called to the witness stand.

The purposes of the hearings had been stated repeatedly by the Committee to be, broadly: To study the relationship existing in actual practice between patent monopolies and competitive conditions within the industry; to determine to what extent the patent law circumvents the anti-trust laws, and to present this data to Congress with the ultimate view of drafting new patent legislation that will maintain free and open markets.

Whether these aims as expressed by the Committee were the true aims of the investigation; whether the hearings were conducted in a manner best calculated to achieve these aims, is a matter upon which comment will be reserved until the concluding paragraphs of this report. At the outset, however, the reader should be reminded that the investigation was in no sense a criminal proceeding on the part of the Department of Justice, but purely a fact-finding probe.

From a glassman's standpoint, it was neither new nor startling to learn that a patent monopoly and a definitely restrictive licensing system exist within the industry. But the story of how it all came about—the

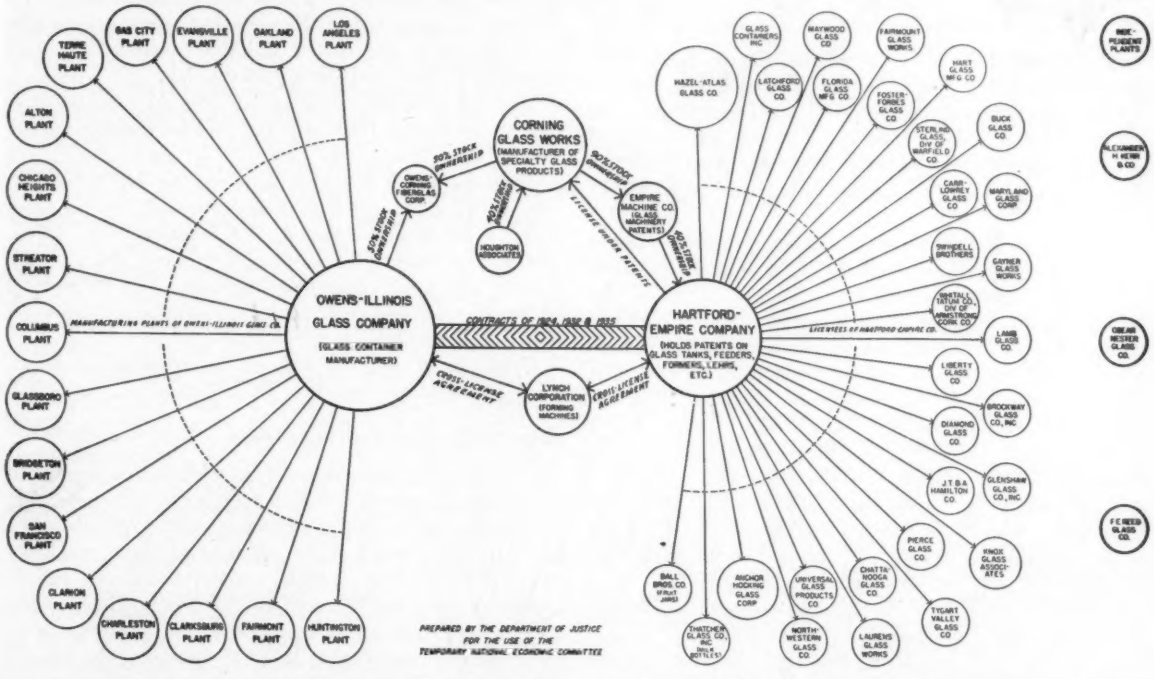


Chart presented in evidence by the Department of Justice to show the inter-relationships existing in the glass container industry. It will be noted that in the case of Owens-Illinois, all factories have been indicated, whereas no factories are shown for the other companies. Of the Owens factories, San Francisco is demolished; Clarksboro dismantled; Terre Haute and Evansville inactive, the latter 10 years; Chicago Heights makes only hand-blown ware; and Glassboro makes closures, not glass.

conferences and correspondence, the particulars of the inter-relationships between the big operators, the deal by which Hazel-Atlas settled its case with Hartford-Empire; the inside story of this drama in which they have been actors, if sometimes unconsciously, is of absorbing interest to all living glassmen.

But we must set the stage and go on with our report. On the front cover of this number of THE GLASS INDUSTRY is a picture of the "court room." From left to right in the background runs a long table at which the T.N.E.C. was seated. At no time was the full committee present. In the center was Chairman Joseph C. O'Mahoney, likable, capable, and who seemed anxious to keep "witch hunting" out of the proceedings; Vice-Chairman Sumners, who with Reece of Tennessee, seemed at times a trifle bewildered as to what it was all about; radical Thurman W. Arnold, Assistant Attorney General of trust-busting fame, who had made up his mind long before the hearing started and let you know it; Borah, liberal and keen for all his years; Federal Trade Commissioner Davis, Lubin of Labor Statistics, and Peoples of the Treasury, judicial in mind and attitude; King of Utah, who sees there are two sides to every story; Patterson, whose Department of Commerce still represents what is left of government's interest in business; Frank, of Securities & Exchange; Executive-Secretary Henderson, Oliphant of the Treasury, all present but seldom accounted for in the hearings.

At right angles to the Committee, on the right and facing both the Committee and the witnesses, sat Chief Counsel H. B. Cox of the Department of Justice, and his staff. Facing the Committee were a table and chairs reserved for the "witnesses"—though Mr. Cox so far forgot himself at one time to refer to them as "defendants."

Hartford's Patents

The dominance which Hartford-Empire exerts over the machinery of glass making dates back to around 1916, when its first commercial gob feeders began to appear on the market. Two of its patents which figured prominently in the testimony were the Stuffing Patent No. 1,655,391 and the Heated Hood or Peiler Patent No. 2,073,572.

The Heated Hood Patent is considered the basic patent covering the art of gob feeding. It embraces the entire concept of feeding suspended charges by the use of viscous glass, the charges being hung up at the orifice until a full charge is accumulated, after which mechanical shears sever the charge and permit it to drop as a unit into the mold. This application was filed in 1914, was issued in 1937, and will expire in 1954.

The Stuffing Patent covers the swelling of a gob in suspension to the desired shape and the shearing of the gob in suspension. This patent adds to the Peiler or Heated Hood Patent the thought that the gob is artificially shaped, or stuffed, before it is dropped in the mold. It was issued in 1928 and will expire in 1945.

It will be noted here that the subordinate patent expires almost ten years before the basic patent. However, it would be a practical impossibility for any one to develop a machine without infringement that would preshape the gob, so long as the gob principle itself is patented. Hence the later patent, in effect, prolongs the life of the earlier patent.

The history of two other Hartford patents disclosed points about patent procedure in which the T.N.E.C. showed great interest; namely, No. 2,073,571 and No. 2,073,572. These were applied for in 1910. For six years they were kept in the Patent Office under consideration by the examiners. Then followed a nine year period during which they were involved in successive interferences. Finally they were rejected, as to some claims at least, and then for another nine years Hartford fought in the law courts to compel the Patent Commissioner to allow these claims and to issue the patents. Hartford succeeded in 1936 and the patent was issued in March, 1937. In all, it had required twenty-seven years for these patents to be allowed—and one could almost hear the Committee murmur: "Too long."

Hartford owns 717 patents. A number of these were taken out on competitive machinery as part of a "fencing in" process. This word first appeared at the hearing as the result of a letter introduced by Mr. Cox and identified as having been written by the late Herbert Knox Smith in 1930. It is a memorandum of policy, taken from the files of the Hartford-Empire Company, and is headed "The Main Purpose in Securing Patents." These main purposes are defined as "(a) to cover the actual machines which we are putting out and prevent duplication of them; (b) to block the development of machines which might be constructed by others for the same purpose as our machines, using alternate means; and (c) to secure patents on possible improvements of competing machines, so as to 'fence in' these and prevent their reaching an improved stage."

Mr. F. Goodwin Smith, president of the Hartford-Empire Company, was on the stand at the time this memorandum was introduced. He called attention to the fact that this letter was a memorandum only; had never been presented to the company, never adopted by it as a policy, and that it did not represent a proper statement of the company's policy today.

Discussion of this "fencing in" process recurred time and again during the testimony and occupied pages of the record. The whole idea can be summarized as a practice by which improvements may be made and patented: (a) upon one's own equipment, so as to cover every possible improvement that ingenuity can devise, and thereby extend the scope and value of the patented device; (b) upon competitive devices, so as to preempt its further development, limit its usefulness, and eventually make it obsolete.

Hartford, in common with all inventors in all industries, has employed the "fencing in" method.

Hartford's License Structure

The Hartford monopoly is essentially a monopoly of the gob-feed method. This presupposes, of course, that gob feeding is the only method by which glass can be taken from the tank and brought to the forming machines mechanically. Besides gob feeders, there are ribbon feeders, stream feeders, and the suction method. That none of these alternate methods figure importantly in the container industry today was brought out by the following percentages of glass container production:

Made under Hartford licenses:	67.4 per cent
Made by Owens machines:	29.2 per cent
Made by independent producers:	3.4 per cent

The Hartford license policy, according to the testimony at the hearings, is to grant licenses that are restricted as to the type of ware the bottle maker may produce. The licenses now in force may be classified by type of ware as follows: 10 milk bottle licenses, of which three are unrestricted as to quantity; 3 fruit jar licenses, all unrestricted; 34 packers' ware licenses, one of which is restricted as to territory; 31 proprietary and prescription; 31 liquor; 26 perfume and toilet; 27 pressure beverage; 32 beer. Outside the container field, Corning has exclusive rights to light bulbs, heat-resistant ware and certain specialties, having secured these years ago.

Prior to 1935, Hartford forming machine licenses contained a clause requiring that they be used only in connection with Hartford feeders; lehr licenses, that these machines be used only with Hartford feeders; stackers, that they be used only with Hartford lehrs. All of these restrictions have been removed from standard licenses issued since 1935, and the testimony indicated that the provisions never had been actually enforced.

Some interpretations of this restrictive policy had an important influence upon the industry at one time in connection with fruit jars for home canning purposes. Container manufacturers began to make packers ware with a finish that would accommodate the Mason or G-type closure. Hartford construes that as a violation of its license, in that the use to which the ware is put determines the kind of license.

All Hartford licenses require as a condition of the contract that the licensee will not contest the validity of the patents under which the license is issued. In other words, to contest a license, on must give up the license—"Go out of business," as Thurman Arnold put it.

The Owens-Illinois Glass Company

The Owens-Illinois Glass Company in its own right is the largest glass container manufacturing company in the United States, producing together with its Pacific Coast subsidiary 38 per cent of the entire output. In addition, the Levis interests own 62 per cent of the Kimball Glass Company, less than 10 per cent of Thatcher Manufacturing Company, 22,000 shares of Hazel-Atlas, 6,644 shares of Lynch Corporation, and an interest in Anchor-Hocking. Owens-Illinois owns stock in the Container Corporation and in the Pennsylvania Glass Sand Company. Mr. William R. Levis is a director of National Distillers and of the W. & A. Gilbey & Company, Ltd., and in 1933 and 1934 was a director of Hazel-Atlas.

Owens-Illinois does not control the sources of its raw materials, although it considered such a policy and finally abandoned it. Jointly with Libby-Owens-Ford, it owns some gas property near Charleston, West Virginia, and independently some other gas properties at Clarington, Pennsylvania. The Company makes most of its own corrugated containers and sells a small portion of its output.

The Owens-Illinois company was formed by a merger of two corporations, the Owens Bottle Company and the Illinois Glass Company. Both had widely different backgrounds with relation to patents.

The Illinois Glass Company had never been in the patent licensing business and, as Mr. Levis testified, in all of its seventy years existence it had never paid a dollar to a patent attorney. The company had always taken out a license from anyone who had equipment it wanted to use, considering such a fee the just due of the man who spent his time inventing and developing. The Owens company, however, owned patents and licensed their use.

Owens-Hartford Relationships

By 1919, the situation was that both Hartford and Owens were in possession of patents which each asserted accomplished the same results. Each was threatened with litigation from the other; neither could make a feeder without fear of a suit for infringement.

To break the threatened stalemate, Owens and Hartford in 1924 entered into a cross licensing agreement on their feeders and feeder-fed machines. Suction patents were excluded. Under the contract, Owens was entitled to the free use of 43 units without restriction of any kind*, one unit representing one feeder and one forming machine. On any machine over this quantity, Owens was to pay a royalty which it was stipulated would be no greater than anyone else would pay. Both companies would purchase other patent rights jointly, and Hartford agreed not to grant any further licenses, except with Owens' knowledge and consent, to any but existing licensees. After a very short life, this last mentioned clause was taken out of the agreement. Finally, Hartford agreed to pay Owens one-half of its divisible income, after first deducting $600,000.

Under this *rapprochement*, Hartford and Owens worked closely together for several years. They jointly bore the expense of patent litigation, as against Nivison-Weiskopf, Kearns-Gorsuch and Obear-Nester in 1926; against Reed, Lamb and Hazel-Atlas. They jointly bore the expense of purchasing the William J. Miller patents and the Tucker, Reeves and Beatty patents, in 1925.

Such was the situation in 1930 when Owens and Illinois merged, and Mr. Levis was made president. By training and inheritance a glassman, he soon found that patents were too much of a distraction from the main business of making bottles, and he set to work to persuade his associates to his way of thinking. As a result, a new contract was made with Hartford in 1932 considerably modifying Owens' participation in the licensing part of the business. Owens-Illinois surrendered its right to 43 free units, and its participation in the Hartford net income was decreased from one-half to a third, after first deducting $850,000. The new contract contained no provision for the joint purchase of patents.

There was still some unfinished business, however. Since 1925, Owens and Hartford had jointly held an option on Whitall Tatum's Headley and Thompson patents. Hartford took title to the patents in 1933, Owens contributing to the purchase. In the same year, O'Neill sold its patent rights, Hartford acquiring the gob feeder and forming machine rights and Owens the suction.

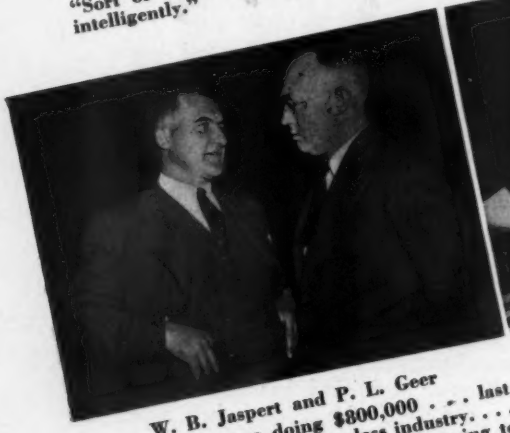
By 1935, Mr. Levis was in a position with his own company to liquidate entirely the patent end of the business. For a cash consideration of $2,500,000 Owens sold a license to Hartford under all of its feeder patents and became a Hartford licensee for whatever feeders it might require, paying royalties in all cases with, however, a "most favored nation clause." It relinquished, also its contractual right to participation in Hartford's earnings.

*The right to use 43 free units was never fully exercised: Maximum number used was 15; 10 at Evansville, 5 at Huntington.

Franck C. Ball and Senator O'Mahoney
"Packers' jars sold in place of domestic jars . . . we thought was unfair competition."

William R. Levis
"Thatcher sets a price on milk bottles, Ball . . . and Hazel on certain lines. We can't ask any more than they, as leaders, ask. And we are not going to take any less, because our ware is as good."

F. Goodwin Smith (right)
"Sort of an A. A. A. in milk bottles . . . but used intelligently."



W. B. Jaspert and P. L. Geer
"In 1928 we were doing $800,000 . . . last year we did $18,000 in the glass industry. . . . We believe we are right and we are going to stick to it."

H. B. Cox and Associates
"If I were to suggest to you . . ."

S. A. Coleman, Jr.
"We were met by a whole trainload of lawyers . . . and in the afternoon we settled our case out of court."

A corner of the Old Caucus Room reserved for witnesses, with the glass men waiting their turn to go on "trial." Seldom in history have so many of the industry's important leaders been gathered together in one place.

Candid Camera Flashes of the Monopoly Hearings

Fibreglas Stopped Them
When Mr. Belknap (center between King and O'Mahoney) passed around samples of fibrous glass, it almost broke up the hearing. The T. N. E. C. couldn't believe it was glass.

L. C. Kingsland
"Obear-Nester has been under constant litigation since 1926—and still is." The company never was "invited to Hartford."

Sidney F. Parham
"We haven't licensed any tanks of our own yet. We hope we are going to have a better one in the near future."

A. M. Pease
To the assistant treasurer of Hartford-Empire, the hearings must have been reminiscent of a marriage ceremony. His entire testimony: "I do."

J. H. McNash
"We didn't change our mind. The Circuit Court of Appeals for the Philadelphia District changed our mind."

Curtis, Falk and Houghton
The vice-president, chairman of the board, and president of Corning Glass works. They are not in the container business.

Today, Owens' position in the container field with regard to Hartford equipment is this: It holds an unrestricted license from Hartford. Of its 17 factories, 11 are operating and one of the idle plants (Terre Haute) is equipped to operate. Only 6 operating factories have Hartford equipment, and these to a very limited extent. Alton, for example, the largest glass container factory in the world, with 10 furnaces, has only 2 Hartford equipped; Huntington, with 5 furnaces, has 2 with Hartford equipment; and Streator, with 11 furnaces, has only 1 Hartford unit.

The Famous Hazel-Atlas Case

Hazel-Atlas Glass Company is the second largest container manufacturing company. It is the largest producer of packers' ware and a major factor in the production of tumblers and table ware. It has only one competitor in the opal jar field.

Though the owner of glass machinery patents, Hazel-Atlas has never licensed any of its equipment. In 1919, it took out a suction license* from the Owens Bottle Company, but according to Mr. McNash, Hazel was never very successful in making wide mouth ware with Owens machines. At one time the Company had seven furnaces operating with Owens machines, but eventually decided to give them up. Beginning at Hazel Plant No. 2, located at Washington, Pa., the Owens machines were replaced with gob feeders, one furnace at a time, and when the job was finished Hazel-Atlas had to shut down two entire factories in order to maintain even a semblance of activity at Washington. This despite the fact that the gob feeders required more labor to operate.

Through one of its wholly-owned subsidiaries, the Kearns-Gorsuch Bottle Company, Hazel-Atlas was sued in 1926 under the Phase Change patent. This was only one of several suits; in fact, to quote Mr. McNash, Hazel-Atlas during these years was in litigation with Hartford "on a wholesale basis," and law suits were costing his company from $50,000 to $150,000 a year in cash, not to mention the time of executives and their distraction from their regular duties.

Finally came the celebrated decision of the Philadelphia Circuit Court of Appeals, wherein Judge Buffington upheld the Hartford Stuffing patent. Hazel-Atlas, in common with most all of the independents, read this decision as the death blow to any further resistance, and concluded that it was just as cheap to pay royalties as to spend the same amount of money in litigation.

Damages, however, were a horse of a different color. Computing these from the date of the original filing of the suit in Pittsburgh, the amount was estimated at between two million and two and a half million dollars. Rather than pay any such sum, Hazel-Atlas felt inclined to carry the suit to the United States Supreme Court, an expense which it was financially able to assume. Moreover, Hazel-Atlas contended that it had a claim against Owens, arising under its license agreement of 1909, by which it was entitled to important gob feeding rights, and that these rights Owens had transferred to Hartford in its 1924 agreement. In addition, immediately after Judge Buffington's decision, Hazel-Atlas had changed over all of its feeders, and this meant more litigation for Hartford. All of this placed Hazel-Atlas in a strategic trading position.

In any event, Hartford and Hazel-Atlas found it possible to compromise their differences and reach an agreement. Hazel-Atlas agreed to pay damages, provided it would "enjoy the same position as Owens." Although all of its gob feeding units except one were Hazel-Atlas built, Hazel-Atlas agreed to pay regular royalties on all of these machines. Hazel licensed to Hartford all of its gob feeder patents. In return, Hartford contracted to pay Hazel-Atlas one-third of its divisible income, over and above $850,000. This contract is now in force and will continue until 1945.

When this deal was originally made, Mr. McNash testified, his company expected it was going to cost them between $100,000 and $200,000 annually, or a sum approximately their annual legal expense. As a matter of fact, from 1932 through the third quarter of 1938, Hazel-Atlas has paid Hartford $5,770,140.97 and in return has received $6,528,660.94, a net gain of about $750,000. Against this must be figured the value of the patents and engineering development which Hazel-Atlas licensed to Hartford.

The Fruit Jar Licenses

Ball Brothers Company is the fourth largest glass company. Its principal item of production in the past has been fruit jars (Ball Mason Jars) for domestic canning, and the Company manufactures about 60 per cent of the entire country's supply. Ball was one of the original Owens licensees, its contract dating back to 1909.

In 1932, Hartford made a determined effort to get Ball Brothers as a licensee. The time was most opportune: The Buffington decision had just been announced; Hazel-Atlas was under license; resistance from the independents had about collapsed.

At that time there were four companies licensed to make domestic fruit jars; Owens and Hazel-Atlas with unrestricted licenses; Salem and Gaynor with licenses limited as to quantity. Ball, influenced by the Hazel-Atlas decision, was willing to become a licensee provided that Hartford would give them an exclusive license "so far as it was in their power to do so."

Hazel was willing to agree to limit its production to 300,000 gross per year, except in case there should be an abnormal combination of circumstances in any one season which would create an unusual demand for domestic fruit jars. This had happened throughout the country in 1930, and locally in New England in 1931. Except for these two years, Hazel-Atlas production never had attained 300,000 gross, so a limitation of this kind would not interfere with its normal operations.

Owens-Illinois was asked to limit its annual production to 100,000 gross. A contract submitted to it containing this limitation was declined. Since 1932, however, Owens' annual production has never exceeded 100,000 gross, which Mr. Levis testified has been due to the fact that whereas "we had thrift in 1932, and cheap sugar and cheap fruit, we will not have such conditions again for some time. That is the only time fruit jars are used." It was also brought out that the use by the housewife of packers' ware for home canning purposes is definitely affecting the market for domestic fruit jars.

With the Owens-Illinois and Hazel-Atlas situations

*Hazel-Atlas gave Owens Bottle one third of its capital stock (500,000 shares) for this license. The shares were repurchased in 1936 for $3,600,000.

settled as best they could be, there remained General Glass as the only Hartford fruit jar licensee. Kerr and Reed Glass also made fruit jars but had not taken out Hartford licenses. Knox was making the Knox fruit jar on the Knox-O'Neill machines. General Glass had an unrestricted fruit jar license, and upon Mr. F. C. Ball's insistence, General Glass agreed to surrender this for $100,000.

This did not end the trouble, however. In the same year Ball complained to Hartford that Mr. Collins was making packers' jars with a finish that would take the fruit jar seal, and was marketing these to the fruit jar trade. Ball Brothers contended that since it possessed an exclusive right to make this type of ware (Owens and Hazel excepted) this was an infringement of their license privilege. Ball Brothers also protested that Glenshaw and Reed were following the same practice.

The record of the hearings does not carry the story much beyond this point. Mr. Collins assured Hartford his packers' ware was not being offered to the fruit jar field. Knox sold its rights to fruit jars on the Knox-O'Neill machines to Ball Brothers for $100,000 the same year. Kerr and Reed are still making fruit jars, but of course are not Hartford licensees.

Knox Glass Associates

The Knox Glass Associates is composed of five affiliated glass companies: Knox Glass Bottle Co., Wightman Bottle and Glass Manufacturing Co., Pennsylvania Bottle Co., Marienville Glass Co. and The Oil City Glass Bottle Co. All five are located in Pennsylvania. The organization was formed on January 1, 1935, and all five of the associates own the stock of Knox Glass Associates in equal amounts. The Associates company performs the sales and engineering service for each of the Associates. In addition to the five there are two affiliate companies, Knox Glass Co. of Mississippi and Metro Glass Co., New Jersey, who handle their own sales independently. The parent company, Knox Glass Bottle Co., owns a stock interest in each of the Associates and affiliates ranging from one-third, in the case of Metro, to entire control in the case of the Mississippi subsidiary.

In 1927, the Knox Glass Bottle Co. joined the Miller Users Defense Organization. This organization was composed of the smaller companies who had purchased outright the William J. Miller feeding devices from the Miller Engineering Co. When Hartford purchased these patents, the M. U. D. A. was formed, employed counsel and defended the patents as not being an infringement on Hartford's patents. Between 1927 and 1932 the M. U. D. A. spent from $130,000 to $140,000 in this defense.

After the Buffington decision and when it became apparent that Hazel-Atlas would not carry the fight to the Supreme Court, the M. U. D. A. collapsed. Mr. Underwood was "invited to Hartford." It was finally arranged that Knox would pay $100,000 as damages, and accepted licenses for 25 units, a quantity since increased to 39. Its milk bottle license was limited to $75,000 gross, but as it proved unprofitable to deal in this type of ware on such a small scale, Knox sold its rights in 1932 to Thatcher.

Knox had been making the Knox fruit jar on the Knox-O'Neill suction machine. It sold out its rights on this type of ware to Ball Brothers in 1933 for $100,000 but continued operating the machines on other lines for a while. Finally, faced with an infringement suit, it agreed to take a license for its Knox-O'Neill machines from Hartford.

Amsler-Morton

Mr. Geer, secretary of Amsler-Morton, testified that his company was in the business of manufacturing glass annealing equipment. From 1915 until 1934 it had built approximately 400 lehrs.

In 1928, Hartford charged the Amsler-Morton Company with infringement, and invited its representative to Hartford. Negotiations for the purchase of the Amsler-Morton patents were unsuccessful.

In 1934, Mr. Geer further testified, his company was approached by the Collin-Norton Company, Toledo, and offered $200,000 and then $260,000 for the business. Still another appointment was made a month later, at which time it was proposed that Amsler-Morton merge with the Simplex Engineering Co. Each of the two companies merged would receive a third interest in a new corporation. An unknown party would take the remaining third, put up half a million capital and guarantee all the Hartford lehr business as well as the Owens-Illinois construction work. Mr. Geer testified he offered to accept the proposal if he were given 51 per cent stock ownership, but the offer was refused.

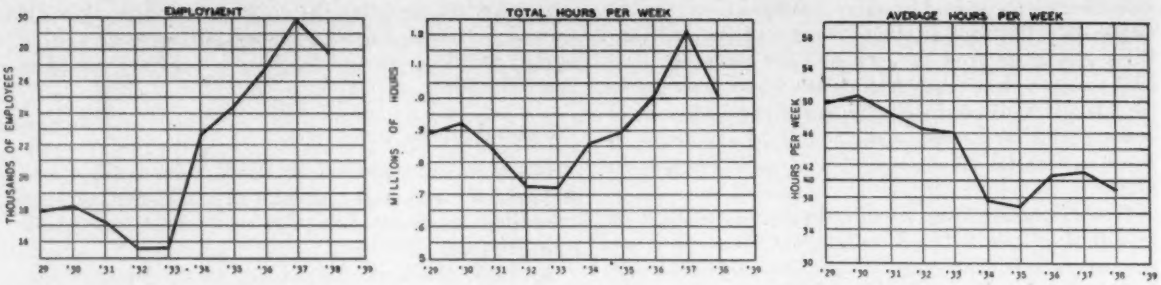
Mr. Geer testified further that his volume of business had declined from $800,000 in 1928 to $18,000 in 1938. Formerly it had manufactured about 20 lehrs a year; in 1934 five, in 1935 four, in 1937 none, in 1938 one.

The Glass Container Industry

According to the testimony of Mr. William R. Levis, it costs about $500,000 per furnace to engage in the manufacture of glass containers. This sum includes the furnace, forming machines, annealing ovens, factory building and packing house. Some of the smaller companies figure the amount under $300,000; Owens-Illinois estimates the cost to be $1,000,000, bringing the average close to half a milllion dollars. To this must be added another $100,000 for compressors, office facilities and machine shop; $400,000 for working capital. The total is close to a million dollars.

And if you are figuring on getting into this business, you should charge about 5 per cent of your sales cost against royalties. For the hypothetical company above, this would mean close to $50,000 per annum. Should the amount seem excessive, it should be compared with the cost of rigging up tools with which to build machines, the machines themselves, legal expense, engineering service, and other benefits received under the license, and if this were done the royalty paid would be found quite nominal. As an example of comparative costs, Mr. Levis testified Owens-Illinois equipped its new Oakland plant with Hartford machines; not because it felt the equipment superior, but because the Company did not care to assume the capital investment for precision tools, etc., necessary to build and service the Coast factories.

Again, if you were planning to become a glass container manufacturer, you might find it good policy to follow the Hazel-Atlas price lists on packers' ware; Ball on fruit jars; Owens on proprietary, prescription, beer and liquor; Thatcher on milk. These companies are the



Employment and payroll data in the glass container industry for one representative week.

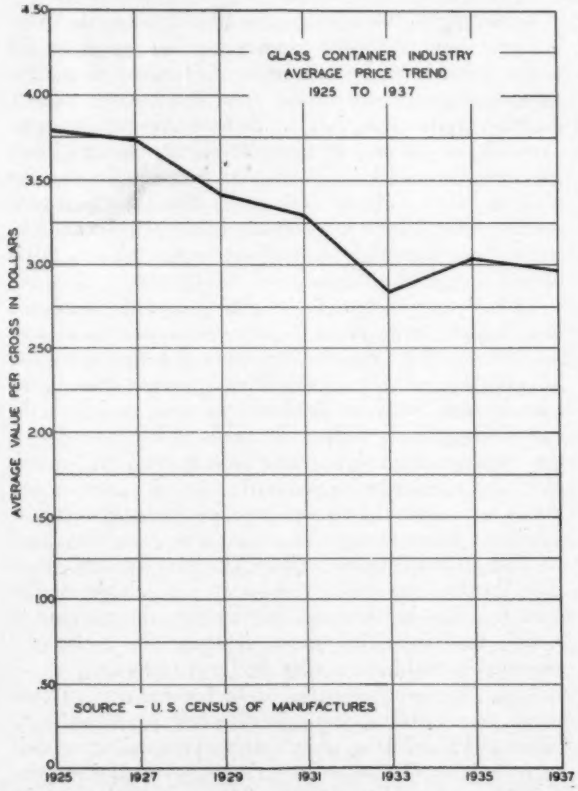
largest producers of those lines of ware. It would be difficult to get more money for your glass than the leader in that particular line. And if your ware were as good as his, you certainly would not want to sell it for less.

Conclusion

The story of the glass container hearings will be read with as many mixed emotions as there are people in the industry. The revelations are bound to arouse animosity, to reopen wounds that time perhaps had begun to heal. Situations were brought to light that would need a further trial to convince the impartial observer that all is as it should be. On such matters, it is not our privilege nor our prerogative to pass any judgment.

What we should consider, what every individual connected with the industry should reflect upon with the utmost gravity, is the relationship the hearings bore to the purpose for which Congress called them.

Congress decreed this investigation in order to find out whether the patent laws were circumventing the *anti-trust laws*. The method it adopted was a type of vivisection—it wanted to see how the wheels go round in an industry operating under "an aggressive patent policy."



The user of glass container has benefited by a constantly decreasing price level.

Before considering this relationship, however, one must take issue at the very outset with T. N. E. C. that theirs was a fact-finding probe. On the contrary, the hearings were conducted so that they would prove certain points which the Department of Justice wished to establish. *These points and no others.* Mr. Cox asked only those questions he wanted to ask; he would not permit the witnesses to develop their side of the story. If a jury wants to ascertain the real facts of a case, it can't succeed by listening only to the prosecuting attorney.

T. N. E. C. waved the banner of "public policy." It has a definite bearing upon public policy to know whether glass container prices have declined continuously under the "managed economy" employed by the glass container industry; that wages have steadily increased—in fact no industry in America has a better record for wages paid, hours of labor, working conditions. The glass container industry wanted these facts introduced into the record, for whatever they might be worth, and the privilege was denied it.

In his opening remarks, Mr. H. B. Cox, chief counsel for the T. N. E. C., made this statement: "The public policy embodied in these (anti-trust) laws rests on the assumption that the maintenance of a free and open market, in which neither production nor price is subject to artificial limitations or control, is socially and economically desirable."

If this states the purpose of the anti-trust laws, then this should be the major objective which Congress should set out to achieve. But is it?

Certainly it is not *per se* a government policy. Otherwise, how explain N. R. A., the A. A. A. marketing agree-

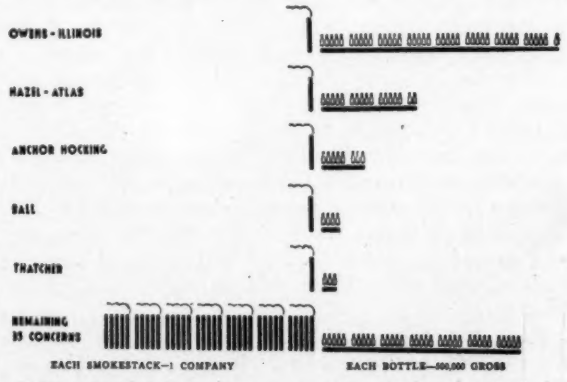
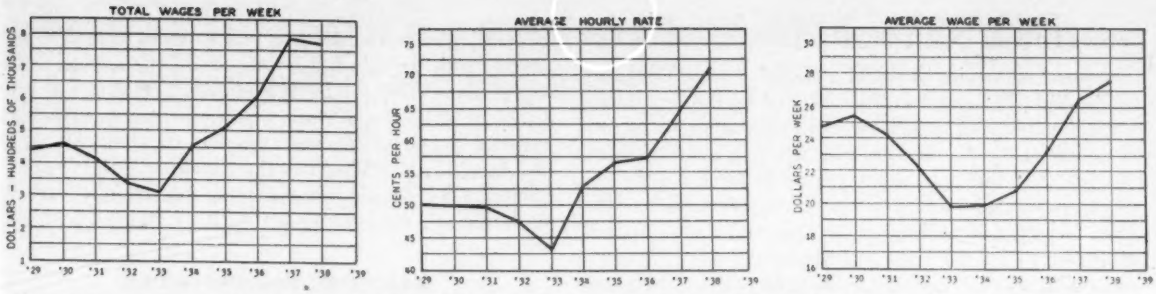


Chart showing the relation as to size of the several glass container manufacturing companies.


TOTAL WAGES PER WEEK
DOLLARS - HUNDREDS OF THOUSANDS
'29 '30 '31 '32 '33 '34 '35 '36 '37 '38 '39
AVERAGE HOURLY RATE
CENTS PER HOUR
AVERAGE WAGE PER WEEK
DOLLARS PER WEEK

This chart and the one facing show that labor has fared well under the "stabilization" policy.

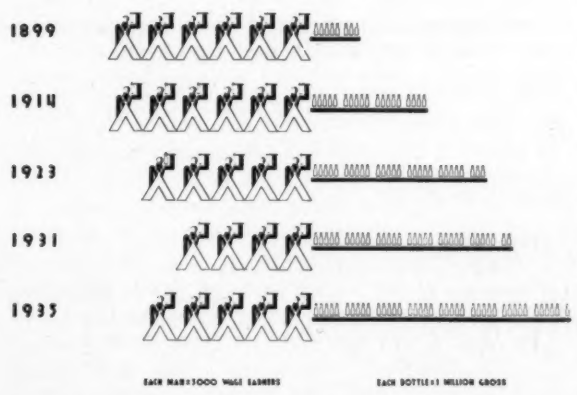
ments, plowing under cotton, the killing of hogs. On the contrary, these recent activities of government prove that it believes in a managed economy—that it believes in the very "stabilization" employed by the glass container manufacturers. But government believes that this control should be a function of the State and not of private enterprise.

We do not have to reason by analogy to prove that this is the aim of government. Read the transcript of the hearings and study the questions asked by Thurman Arnold. Mr. Arnold has been interviewed time and again by the press, including THE GLASS INDUSTRY, and his views are a matter of public record. Arnold wants the State to participate in the management of industry.

And where does this lead to?

Some of those who testified at the hearings demonstrated quite thoroughly that the patent laws had permitted others, by perfectly legal means, to keep them from conducting their operations with the full freedom they felt they were entitled to. Whether or not their grievances were just grievances was irrelevant to the investigation, except as their experiences relate to the public interest. And when we are brought to the question of public interest, we find an important element in Congress so intent upon finding a pretext for government to participate in business that any legislation it enacts may produce greater evils than those it seeks to correct.

It is upon this phase of the hearings that industry, all industry, should fix its attention.



In 1899, there was no glass making machinery of any consequence. Modern methods of production did not really come into use until after 1914. Although glass making machinery has increased tremendously the output per man, the total number of wage earners employed has suffered less than would be expected.

AS LABOR SEES THE HEARINGS

In order to ascertain the attitude of labor with respect to the hearings, THE GLASS INDUSTRY requested a statement from Mr. James Maloney, president of The Glass Bottle Blowers' Association. Mr. Maloney stated as follows:

"The T.N.E.C. hearings were deemed of sufficient importance to warrant sending our national treasurer, Mr. Robert G. Vansant, and also one of our executive officers, Mr. Thomas Eames, to be present as observers.

"Although the licensing system in use throughout the glass container industry was under heavy fire, we ourselves, as representing labor in that industry, have no fault to find with it and on the contrary the system has been beneficial in many ways.

"Licensed corporations as a class are far more responsible. They have the financial and the moral integrity to carry out the contracts into which they enter. In former years, when there were many companies operating with inadequate capital and without adequate glass making experience, it frequently happened that members of the Bottle Blowers' Association were unable to collect the wages they earned.

"Particularly at the time when the Prohibition Amendment was repealed, we were glad that the licensing system prevailed. At that time there was a large number of promoters who believed that the manufacture of beer and liquor bottles offered them a gold mine. We had many experienced glassmen in the cities where glass plants were already established, out of work, and needing employment. These men had suffered during the hard times. Had the promoter type factory been permitted to do business, it would have resulted not only in a dislocation of employment; but when these firms failed, as many undoubtedly would, labor would have been left holding the sack.

"In the early years of the glass business, a man could start a glass factory almost in his own backyard, at an expense of a few thousand dollars. It is quite different now. In order to start a plant which has any prospect of competing with the already established manufacturers, the new plant must be prepared to invest at least $250,000, and even then, it will be dependent upon adequate working capital to continue successfully.

"Under the existing system, the bottle blowers have been provided with reasonably steady work. Their working conditions have been constantly improved, and they have been able to earn a fair living wage. Notwithstanding these advantages which the workers have gained, the selling price of glassware has continually gone down."

ARMSTRONG CORK PURCHASES HART GLASS

The purchase of the Hart Glass Manufacturing Company of Dunkirk, Indiana, has been effected by the Armstrong Cork Company of Lancaster, Pa., according to an announcement by H. W. Prentis, Jr., president of Armstrong. The Indiana company manufactures a wide line of glass containers and employs about 500 persons. The Hart factory will continue to be operated by the present management but the Hart and Armstrong sales organizations will be combined just as soon as practicable. Francis H. May, former general manager of Hart Glass, will become the new head of the glass department of Armstrong's glass and closure division.

Purchase of Hart Glass Manufacturing Co. follows the acquisition by Armstrong on June 20th of the business of the Whitall Tatum Co. whose plants were located at Millville and Keyport, N. J. The Armstrong Cork Co., founded in 1860 as a manufacturer of cork bottle stoppers, has long been an important factor in the making of closures for glass containers and the purchase of the two glass companies rounds out their packaging service.

CERAMIC CAMERA CLUB NOW FORMING

Camera fans who are also members of the American Ceramic Society will welcome the announcement of the formation of the Ceramic Camera Club, a new and informal organization projected by a number of the photography-minded members in the society. The immediate objective of the club is to hold an exhibition of the work of its members in Chicago at the time of the annual meeting of the American Ceramic Society, but the aims of the club are strictly social and photographic and it will have no official connection with the society.

The sponsors of the new club include such expert camera-wielders as J. M. McKinley, J. C. Hostetter, J. Earl Frazier, H. M. Kraner, J. T. Littleton, E. L. Hettinger, Raymond Kerr and others. All knights of the lens who also happen to be A. C. S. members are being invited to join in the formation of the Ceramic Camera Club and to take part in the exhibit at Chicago. Those who have taken up photography more recently are particularly urged to join in this activity, not only to make the show truly representative, but also to participate in the technical benefits provided by projected club discussions and other cooperative efforts.

The rules governing the proposed Chicago show are very simple. It is proposed that each member shall send in, at the proper time, from one to four prints, the subjects being left entirely to the discretion of the individual exhibitors. The display space and equipment available makes it necessary for each print to be submitted on a 16 in. by 20 in. vertical mount and no other size or type of mounting can be accepted. Tentative plans for the selection of a jury of prominent Chicago photographers, and the presentation of an award for meritorious work, are being considered. It is hoped that the show will include a good proportion of technical subjects, as well as pictorial.

As yet, the Ceramic Camera Club has no formal organization, but a volunteer committee is going ahead with plans for the initial activities at Chicago. Outside of the exhibit no formal meeting is proposed, but an informal dinner meeting, at some time which will not conflict with the scheduled program of the annual meeting of the society, is being planned. So that the necessary exhibition space and equipment can be provided and that the committee can complete its plans, all those who intend to participate in the activities of the Ceramic Camera Club should communicate immediately with J. M. McKinley, 1012 National City Bank Bldg., Cleveland.

MAKES GLASS INVISIBLE

Discovery of a method by which glass could be made invisible was announced on Dec. 26, 1938, by Dr. Katharine B. Blodgett of the General Electric Laboratories. Twenty-four hours later Dr. C. Hawley Cartwright of the Massachusetts Institute of Technology announced that he too had succeeded in achieving the same result by a different method.

Dr. Blodgett is a co-worker of Dr. Irving Langmuir, Nobel prize winner, who found that an oily film of the thickness of a single molecule could be spread upon the surface of water. This piece of pure research seemed to be of no particular value, but Dr. Blodgett has taken glass, dipped it through the oily film and transferred it to the glass. Each dip adds a new layer of film. According to the Associated Press report from which this information was taken, it usually requires 44 dips of a piece of glass to build a film the thickness of a quarter wave length of light.

The M. I. T. experimenters made their film from sodium or aluminum fluoride. This was heated until gas was generated and the gas allowed to settle on a glass plate. The resulting film had the same approximate thickness as achieved by the General Electric experimenters.

It is stated that films of a quarter wave length are just the right thickness to cause the crest of one wave to overlap the trough of another as light is reflected. The result is a cancellation of wave motion. This "cancellation" of reflection does not result in any loss of light, the news dispatch continues. The light that ordinarily would be reflected passes on through the glass.

PRODUCTION FIGURES FOR THE GLASS INDUSTRY DURING NOVEMBER

Glass Containers: Production of glass containers during the month of November, 1938, was 3,709,379 gross, bringing the 1938 total to 39,582,632 gross. Shipments during November were 3,491,251 gross, bringing the 1938 total to 40,335,588 gross.

Plate Glass: The production of polished plate glass by member companies of the Plate Glass Manufacturers of America during November, 1938, was 12,883,448 sq. ft., as compared to 12,868,717 sq. ft. produced in the preceding month, October, and 12,517,311 sq. ft. produced in November, 1937. This makes a total of 73,034,657 sq. ft. produced during the first eleven months of 1938.

Window Glass: During November, 1938, the production of window glass was 882,595 boxes, which represents 54.4 per cent of industry capacity. As compared with this, November, 1937, production was 1,095,267 boxes, representing 70.7 per cent of industry capacity.

AN ATTEMPT TO CORRELATE SOME TENSILE STRENGTH MEASUREMENTS ON GLASS

By JAMES BAILEY
Hartford Empire Co.

INTRODUCTION

Vast numbers of measurements of the tensile strength of glass have been made and recorded in the literature, and yet any attempt to correlate the results obtained leads inevitably to a series of irreconcilable conclusions. In very small threads the strength may reach an indicated value of one and one-half million pounds per square inch, while larger pieces may fail at stresses below four thousand pounds per square inch. The results obtained by any experimenter seem to be more a function of his method of testing and of his method of preparing his samples than of the strength of the glass itself. Nevertheless, glass is one of the most uniform and homogeneous materials and it should be possible to measure its strength and to discover the laws of this very important property, so that the numerical values obtained have some useful significance. This paper represents an attempt to correlate some of the divergent results of published tensile strength measurements of glass.

One of the disappointments encountered at the very start of an attempt to analyze an assortment of tensile strength measurements is the discovery that many of the necessary factors which affected the strength have been omitted from most of the published results. In others, a false significance is placed upon factors which had but a minor effect upon the result. For example, it is quite common to find data in which tensile strength is plotted against the diameter of fine fibers without giving either the length of the stressed portion of the fiber or the rate of application of the load. The omission of these factors makes the data essentially useless, as will be shown in later sections of this paper.

Likewise, we have published data of strength vs. size of test piece, in which it is shown that the strength decreases as the size increases, but in which the *rate of application of stress*, which may have been one of the most important factors, has been entirely neglected.

The data on the bursting strength of bottles are almost always given in pounds per square inch of internal pressure, the only data on the bottle itself being the type, the capacity, and the weight, whereas the minimum wall thickness, the inside diameter, and the rate of application of the internal pressure are perhaps the controlling dynamic elements of the experiment.

As long ago as 1920, A. A. Griffith[1] recognized that the strength of most materials is controlled by the flaws which they contain. This concept is now quite generally accepted, and, in the case of glass, there can be no doubt that it is true. Flaws act as stress magnifiers and their size, their position with respect to the stresses, the probability that they will occur in the region of stress, and their type, are all controlling factors in the measured strength.

Since we cannot measure the flaws, their effect must be deduced from the experimental results, and to this end the data should contain the following pertinent facts:

1. Kind of glass; chemical composition, if possible, and method of melting.
2. Annealing, heat treatment, etc.
3. Method of manufacture, as drawing from molten glass, blowing, kind of moulds, etc., if an article.
4. Method of preparing sample, if a test piece.
5. Pertinent dimensions of the test piece, with drawings, if a bottle, so that results may be reduced to units of stress.
6. A description of the apparatus, with details of holding device, if used, location of diamond cuts on specimen, etc.
7. Detailed method of testing, with the necessary information so that the initial stress, the rate of application of stress, and the breaking stress may be computed, and the time factor is completely known.
8. Any peculiarities of shape.
9. Any observable defects, such as scratches, bruises, weathering, etc.
10. Character of break, if abnormal.

The importance of many of the factors which affect the strength has not been recognized in the past, and hence most of the published data do not contain enough of the pertinent information to be of use in an attempt to study the effects of the isolated single factors. However, there are enough such data to enable a rather limited study of them to be made.

Almost all of the strength data which are complete enough to be of use have been confined to lime glasses of the window glass, plate glass and bottle types. The effect of chemical composition seems to have been entirely covered up by other more important considerations. This factor cannot be dealt with until some better method of interpreting the results of the measured strength has been found. It will therefore be neglected in this paper.

The effect of thermal treatment must likewise be omitted although it is known that "thermal toughening" may raise the strength to three or four times that of the same specimen in the annealed state. This way of controlling strength should be considered individually in view of the present uncertainties regarding the physics of the problem.

The present study of the tensile strength of glass will be confined to commercially annealed glasses of the common soda lime silica types.

It will be assumed that the measured strength depends upon the character of the flaws which the test piece contains, that these flaws magnify the applied stress, and

[1]Griffith, A. A., "The Phenomena of Rupture and Flow in Solids," *Philosophical Transactions*, Royal Society of London, Series A, Vol. 221, pp. 163-198. (Harrison & Sons, London, 1920). This paper is a remarkable example of what can be found by systematic experiment and the application of theory.

that breakage occurs when the stresses at the apexes of the flaws reach a certain maximum value.

The strength will therefore depend upon:

1. The weakening effect of the flaw, which may be visualized as being its physical size. Since the most weakening flaw (the largest one) causes breakage, this flaw controls the "stress level" of strength.
2. The probability that a large flaw will (a) occur in the region of stress, and (b) will be oriented into its most weakening position.
3. The time that the stress is applied, since experience has shown that this is a major factor.

The first of these (the stress level factor) is probably associated with the manufacturing process, the handling and the surface treatment of the test piece. Numerically, it is a ratio of initial strength to strength found. The second (the probability factor or area-strength relation) is largely a function of the size of the test piece, the stressed area of the test piece, and the direction of stress; hence it depends partly upon the method of testing; it is some function of area. The third (the strength-time relation) is entirely a detail in the test procedure. It must be reduced to units of stress and time.

If these three factors can be separated from the data and evaluated, it should be possible to correlate the divergent tensile strength values of glass. We shall proceed on the assumption that the measured tensile strength is the product of these three functions.

It is only fair at this time to state that the author has not been entirely successful in correlating the results, having found that bottles and pressure containers in general are too weak, whereas fine fibers are too strong. Nevertheless, it is believed that much has been done to enable formation of a useful concept of the numerical value of the measured tensile strength of glass.

I: THE AREA-STRENGTH RELATION

If the results of an assortment of tensile strength measurements on glass are compiled, certain characteristics may be readily observed, such as the following. A very wide spread in the individual values making up any one average will be found. The strength obtained on the same glass by different methods of testing will be very different. The character of the surface will be a major factor of the strength. It will also be found that the size of the specimen exerts a controlling influence on the strength, large pieces being weak and very small pieces being disproportionately strong.

The prime reason for making tensile strength measurements on any material is to provide engineering data which will be useful in estimating the strength of an object made of the material. It is evident from the above that the average tensile strength of glass found by direct testing cannot be taken as a useful engineering constant. There are other factors which must be taken into account.

If, however, the data are analyzed from the premise that the strength of glass specimens is controlled by the flaws in them rather than by the strength of the body of glass itself, a way out of the apparent conclusion is opened.

It has been found experimentally that rupture in a stressed piece of annealed glass starts at the surface. If flaws are responsible for the strength, it may be assumed that only those flaws which outcrop at the surface need be considered, and the probability of obtaining a flaw in the stressed region of the specimen becomes a function of the stressed area. It therefore follows that the stressed area may be taken as a function of strength.

The purpose of this chapter is to derive a relation between the strength and the stressed area in one lot of test pieces and to explore its usefulness.

Many writers[2] have hinted that a relation between the area and the strength existed, but none of them has derived the relation or outlined the possible use that such a relation might have. It is not, however, a difficult matter to derive a relation, very useful from an engineering standpoint, between the average strength and the stressed area of any group of test pieces.

Consider a very long rod of glass of length L (Fig. 1), stressed in tension by a force P. The surface of this rod is covered with flaws which may have been caused by a number of factors such as inhomogeneities in the glass, surface dirt or surface injuries. These flaws, no matter from what cause, act as stress magnifiers and determine the breaking strength of the glass. For purposes of discussion, let the most weakening flaws be designated by the letters a, b, c, d, etc. The stressed area of the rod is evidently $2\pi RL$, and all of the flaws outcrop somewhere in this surface. If the force P is gradually increased, the stresses at the apex of each flaw will also increase. At some critical value of P the stresses at the apex of one of the flaws (call it *a*) will cause rupture of the rod. The strength Sa will be computed by dividing P by πR^2. This obviously is the least strength that can be found for the particular rod tested since all other parts of the rod withstood the load.

Suppose that the rod had been cut into two pieces of length ½ L, and each piece had been tested in the above manner. Then the left hand half would have a strength of Sa with a stressed area of $2\pi R \times \frac{L}{2}$. The other piece would have a strength of S_b, where b is the most weakening flaw in the right hand half. The average strength of the two pieces of the rod would be ½ (Sa+Sb), and this value would be greater than Sa since Sb must be greater than Sa.

If the rod had been cut into three sections and each piece tested, the average strength would be ⅓ (Sa+Sb+Sc), and this value would be greater than either of the others, since $Sc > Sb > Sa$. The stressed area of each piece would be $\frac{2}{3}\pi RL$.

By analogy, the average strength of any number of pieces cut from this rod would be:

$$S = \frac{L}{n} (Sa + Sb + Sc - Sn)$$

and the stressed area S_a will be:

$$A_n = \frac{L}{n} (2\pi R)$$

and S is greater than any average strength found when the rod is cut into a lesser number of specimens, since:

$$Sn > \ldots\ldots\ldots > Sc > Sb > Sa.$$

The highest average strength will therefore be associated with the test piece of the smallest size.

[2]Griffith, Preston, Grenet, Gooding, etc.

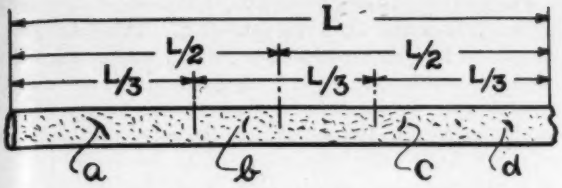


Fig. 1. Showing why the measured strength depends upon the length of the test piece.

If instead of one long rod the specimens had been made from X long rods of the same diameter, each cut up into specimens of L, L/2, L/3, and so forth, a similar line of reasoning would lead to the conclusion that the average strengths found would be identical for the same length of test piece when each long rod was typical. In practice, however, the rods do not all have a typical flaw distribution and the average value will shift somewhat according to the number of specimens tested; the greater the number, the more representative will be the average values. The greatest strength, however, will always be associated with the shortest specimen.

In the above case the strength might be associated with length instead of area, but it is obvious that this can be done only when the rods are tested in tension. The most common method of determining the strength is by applying a bending moment to the glass specimen, and in this case the stressed area must be considered since this area depends upon the shape of the test piece and the knife edge arrangment, as well as upon the length.

A modulus of rupture test on rods of glass is usually made on specimens cut to the same length. If these rods are of the same approximate diameter, and are tested under identical conditions, it is possible to determine the strength-area distribution of the original rods by a somewhat different procedure. This determination is made more involved by the fact that the stress in a specimen tested by cross bending varies from point to point, and the useful stressed area is consequently indeterminate.

The process has been applied to a series of tests which recently became available to the author through the courtesy of the Hartford-Empire Company[3]. The series used is marked "Run No. G," and consisted of 103 tests all made at a loading rate such that the stress increased uniformly at a rate of 3,200 lbs. per square inch per minute. The rods were tested by bending across outer supports 4" apart and were loaded by two central knife edges 2" apart; the center two inches, therefore, had a uniform bending moment. The rods were approximately ¼" in diameter and 6" long and were made of lime glass. Each specimen was carefully measured and its strength computed. The data were recorded for each specimen.

Statistical analysis of these data gave, when grouped in intervals of 300 lbs./sq. in:

	lbs./sq. in.
Mean	11,350
Standard deviation	1,623
Standard error of mean	160
Number of samples	103

The data are plotted in Fig. 2. Normal distribution is not shown. The minimum, average, and maximum individual values were 6,895; 11,350; and 15,818 lbs./sq. in. There was evidence of two peaks, at 10,300 and 12,800 respectively. Although the statistical analysis showed that the lot of test pieces was abnormal in some respects, the strength values were, nevertheless, used to work out the strength-area relation of this lot of rods.

The stress distribution throughout a specimen tested in bending is very complicated. Only a small part of the glass is subjected to an order of tensile stress approaching the maximum, and but a small part of the surface of the glass specimen is adjacent to glass having high tensile stresses. Any flaw in this highly stressed part of the surface will cause failure as soon as the stresses at its apex become sufficiently great. The surface covering this part may be called the "stressed area" of one rod. Without attempting to define this area in square inches, it is obvious that this area contains but a very small part of the total flaws on the surface of the specimen.

If the same knife-edge distances were used and the same rate of stress increase were applied, and if two rods had been tested side by side at the same time, each bearing an equal part of the load, both would break as soon as the weakest gave way,[4] because the remaining rod could not support the total load. Under these conditions, the stressed area would be twice that of a single rod, and the average strength found would be that corresponding to a test piece having twice the stressed area of a single rod.

The result can be computed from the data by arranging the individual test values, in all possible groups of two, and finding the average of the sum of all the weaker values in each group.[5]

In like manner, the mathematical averages of the values for the weakest rod in all groups listed in Table I were computed.

[3]Transverse Breaking Strength Tests for A.S.T.M. Glass Section—Sub-Committee V, Committee D-9, Hartford-Empire Co., Hartford, Conn. June 12, 1936. These tests were undertaken by various members of the Glass Division of the American Ceramic Society.

[4]This is not strictly true, since the strongest test piece is more than twice as strong as the weakest one. The number of times that this could happen, however, is so small, that the statement may be taken as correct, for the purpose of this discussion.

[5]The behavior of the rods in various groups is analogous to that of a chain in which each test piece corresponds to one link and the number of links in the chain is the number of test pieces in each group. The strength of the weakest link determines the strength of the whole. This problem has recently been solved by F. W. Preston and T. C. Baker (Butler, Pa.) using statistical methods. Private communication.

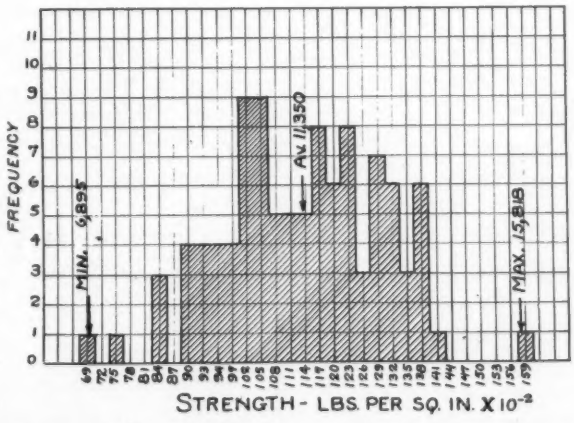


Fig. 2. Distribution curve for data in Run G arranged in intervals of 300 lbs. per square inch.

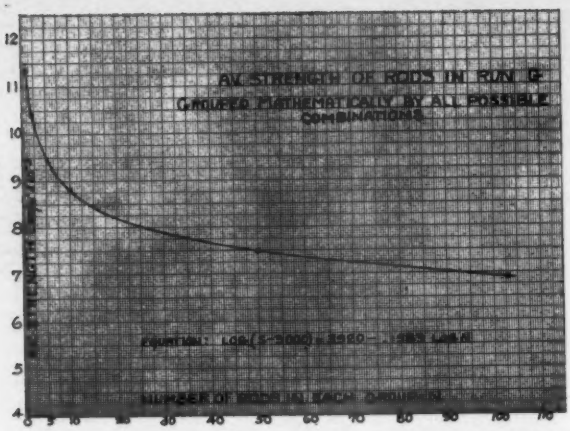


Fig. 3. Average strength of rods in Run G grouped mathematically by all possible combinations.

TABLE I. AVG. STRENGTH OF COMPUTED VALUES OF N

N^x	$S^* = Av.\ Strength$	*Remarks*
1	11,350	Average strength in tests.
2	10,424	Computed
10	8,805	Computed
50	7,480	Computed
103	6,895	Lowest value found.

N^x = number of rods in each group

S^* = average strength, pounds per square inch

Data of Table I are plotted in Fig. 3. For purposes of extrapolation the data were reduced to an equation:

$$\text{Log } (S - 3000) = 3.920 - 0.1583 \text{ Log } N$$

The agreement of this equation with the above values is given in Table II.

TABLE II. COMPARISON OF STRENGTH FROM TABLE I WITH VALUES OF STRENGTH COMPUTED FROM EQUATION (1)

N	*S (Table I)*	*S from Equation*	*Error*
1	11,350	11,318	−32 = − .28%
2	10,424	10,452	+28 = + .27%
10	8,805	8,777	−28 = − .32%
50	7,480	7,478	− 2 = 0
103	6,895	6,993	+98 = +1.4%

Fig. 4 shows a graph of the strength vs. "Area-Function in Test Rod Equivalent Units." This graph permits the estimation of the strength value which would have been found if the rods had been tested as outlined in any size grouping.

Before this can be put to practical use, the "Stressed Area" of one rod must be found in definite area units: a tedious and somewhat uncertain process. The first step was to find the area of the specimen which was above some fraction of the maximum stress. This was done graphically and the results are also listed in Table III.

TABLE III. AREA-STRESS DISTRIBUTION FOR "RUN G" RODS DURING TESTING

(Run G)	*Area in Square Inches above Stress Greater Than*		
% of Max.	*Outside Central Knife Edges*	*Between Central Knife Edges*	*Total Area*
100	.0	.0	.0
98	.0012	.097	.098
97	.0025	.1175	.120
96	.0038	.14	.1438
94	.0067	.171	.1777
92	.0104	.1975	.2079
90	.0152	.2225	.2377
88	.0202	.245	.2652
86	.0257	.265	.2907

The areas in column two are the same as those for one central knife edge when the span is 2". This table can be used to find the stressed area for any round rod with any knife edge arrangement by simple multiplication and division. The useful stressed-area was selected from this list by comparing the strength of the same rods loaded with one single knife edge with that of the double knife edge arrangement, used in Run G. Unfortunately the Hartford-Empire Co. did not determine the single knife edge strength, hence Corning's figures[6] were used for this purpose as follows:

Corning's strength 10.66 Kg/mm² = 15,160 lbs./sq. in. (using single central load)

Corning's strength 7.25 Kg/mm² = 10,310 lbs./sq. in. (using double central knife edges)

The loading rate in the single central knife edge was 6,400 lbs. per square inch per minute, while that of the double was 3,200 lbs. per square inch per minute. If the single value is corrected for rate of loading by ratio from Black's[7] curve, it becomes:

$$15{,}160 \times \frac{6940}{7010} = 15{,}000 \text{ lbs./sq. in.}$$

when the rate of loading is 3,200 lbs. per square inch per minute.

The change in strength therefore due to the change in the stressed area is:

$$\frac{15{,}000}{10{,}310} = 1.455$$

The average strength for one rod in Run G was 11,350 lbs. per square inch. The strength of Run G rod loaded with a single central knife edge would have been

$$11{,}350 \times 1.455 = 16{,}510 \text{ lbs.}$$

This strength occurs when N in Fig. 4 is 0.47 part of one rod.

The next step is to construct Table IV showing the corresponding stressed areas for the single and double knife edge arrangements.

[6]Tests made on a group of the same lot of rods by Corning Glass Works, Corning, New York, during cooperative tests for A.S.T.M.

[7]See citation No. 19.

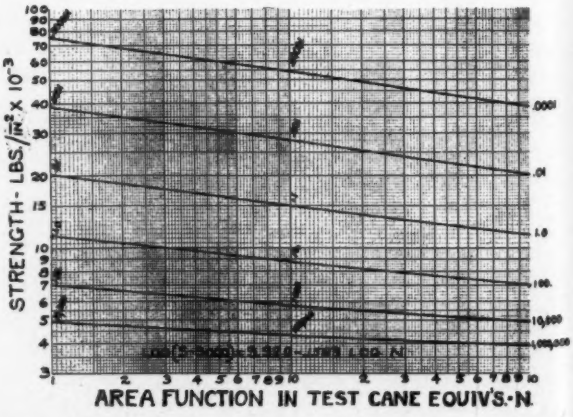


Fig. 4. Extrapolated values of Strength vs. "N" from equation.

TABLE IV. CORRESPONDING STRESSED AREAS FOR SINGLE AND DOUBLE KNIFE EDGE LOADING

1	Stressed area above			
% of Max.	2 Single Central	3 Double Central	4 Ratio	Sing. Doub.
100	0	0	....	
98	.0024	.098	.0245	
97	.005	.120	.0417	
96	.0076	.1438	.053	
94	.0134	.1777	.075	
92	.0208	.2079	.100	
90	.0304	.2377	.128	
88	.0404	.2652		
86	.0514	.2907		

2 is the area corresponding to ¼" diameter, 4" span, one central knife edge.

3 is for ¼" rods, 4" span, two central knife edges 2" apart.

By plotting the values in column 1 against those in column 4 and locating the ratio .047 the stress which defines the useful area function of the rods is bound to be approximately 96.5 per cent of the maximum stress. These computations are admittedly rather indirect and might easily be subject to considerable error. The author has checked this result in several other ways, and finds that 96 per cent of the maximum stress results in an area function, which seems to fit actual results more closely. He has therefore tentatively adopted the 96 per cent area as the one to use for all comparative strength figures. This area is 0.1438 square inches for the rods in Run G. This knowledge enables computation of the strength of these rods tested under any conditions of knife edge arrangement so long as the rate of loading is kept constant.

For single central knife edge loading, let

l = the span in inches

l_1 = half the span

A = stress area above 96 per cent maximum stress

SR = the stressing rate, lbs./sq. in./ min.

$$AF = \text{Area Function} = \frac{A \text{ (sq. in.)}}{.1438 \text{ (sq. in.)}} = N \text{ in Fig. 4}$$

LR = rate of loading in lbs./min.

S = strength that would be found, lbs./sq. in.

Then the theoretical values of S are given in Table V. They are found by reading the strength corresponding to the area function (N) in Fig. 4, and therefore are the strengths which the rods have when tested at a rate of increase of stress of 3,200 lbs./sq. in./min.

TABLE V. DEPENDENCE OF STRENGTH UPON DETAILS OF APPARATUS AND TEST PROCEDURE

l	l_1	A	SR	AF	LR	S	S_1	S_2
12	6	.0228	3200	.1585	1.64	14,200	9,600	15,350
10	5	.0190	3200	.132	1.97	14,500	8,000	15,450
8	4	.0152	3200	.106	2.46	14,900	6,400	15,600
6	3	.0114	3200	.079	3.28	15,500	4,800	15,800
4	2	.0076	3200	.053	4.91	16,200	3,200	16,200
2	1	.0038	3200	.0264	9.83	17,800	1,600	17,300
1	½x	.0019	3200	.0132	19.66	19,500	800	18,500
½	¼x	.00095	3200	.0066	39.32	21,400	400	19,800

x Rods of these ratios of lengths to diameters would give abnormal results owing to the lack of pure bending stresses.

The columns headed S_1 and S_2 do not properly belong in this section of the paper. S_1 is the rate of stress increase in lbs./sq. in./min. which would be developed if the load had been increased at the uniform rate of 4.9 lbs./minute. S_2 is the strength in lbs./sq. in. which would be developed if it were corrected for rate of stressing as will be given in another chapter (Then see Fig. 15).

Rods in Run G Tested in Direct Tension

If, instead of testing the rods in bending, they had been tested in direct tension, all of the surface would have been adjacent to glass bearing the maximum stress. The surface defining the stressed area would then be the circumference multiplied by the stressed length, and all of the stresses would be adjacent to uniformly stressed glass. This is quite different from the case of the specimen during a transverse test where the stresses vary rapidly from point to point. If the flaw pattern were definitely known, it might be possible to arrive at an area unit in the direct tensile test which would correspond to the stressed area of the transverse test specimen. But with the knowledge at hand it would be unwise to attempt this.

However, it would seem reasonable to suppose that the area unit of 0.1438 square inch which defined the unit flaw area of the transverse test piece would also define the unit stressed area of the same rods tested in direct tension. By this assumption the length of the ¼" diameter rod which would have an area of 0.1438 square inch and a strength of 11,350 lbs./sq. in., when the stress increases at the rate of 3,200 lbs./sq. in./min., is 0.183 inch. The area function (N) for any length may be found by dividing the stressed length by 0.183 and the corresponding strength can then be read directly from Fig. 4. The following strength values were obtained in this way.

TABLE VI. THEORETICAL STRENGTH OF RUN G RODS IN DIRECT TENSION

Inches of Stressed Length	Corresponding N	Strength lbs. per sq. in. (Fig. 7)
.183	1	11,350
1.0	5.46	9,400
2.0	10.9	8,700
5.0	27.3	7,950
10.0	54.6	7,500
100.0	546.0	6,000

The Theoretical Tensile Strength of Any Rod Having a Run G Flaw Pattern

Fig. 4 may also be used to find the theoretical tensile strength of rods having the same flaw-area pattern as those of Run G, but having different diameters and lengths. N is first found by dividing the stressed area of the test piece by 0.1438 square inch. The corresponding strength may then be found in Fig. 4.

For purposes of illustration, the strength of an assortment of test pieces has been computed by the above method. The high strength of the small test pieces again emphasizes the necessity of recording both the diameter and the stressed length of the test pieces.

TABLE VII. COMPUTED AVERAGE STRENGTH OF RODS HAVING FLAW PATTERN OF RUN G TESTED IN TENSION

Diameter	Length	Area (Sq. in.)	N	Strength (lbs. sq. in).
0.5 mm	0.5 cm	.0122	.0848	15,300
1 mm	1 cm	.0488	.339	13,000
1/16 in.	¼ in.	.049	.341	12,900
1/16 in.	1 in.	.196	1.36	10,900
1/16 in.	2 in.	.392	2.72	10,200
1/8 in.*	½ in.	.196	1.36	10,900
1/8 in.	1 in.	.392	1.73	10,700
1/8 in.	2 in.	.785	5.44	9,400
3/16 in.	½ in.	.294	2.04	10,400
3/16 in.	1 in.	.589	4.10	9,700
3/16 in.	2 in.	1.178	8.19	8,950
3/8 in.	1 in.	1.178	8.19	8,950
3/8 in.	2 in.	2.356	16.4	8,330
3/8 in.	10 in.	11.78	82	7,170
½ in.	1 in.	1.57	10.9	8,700
½ in.	2 in.	3.14	21.8	8,100
½ in.	10 in.	15.7	109	7,000

"SOLD"

By ALF. Q. WARTZ, Ing.

That ingratiating "mineralogic royalist," Adam D. Bunker, was properly taken to task by Paul Emic in his biting invective in the November issue of GLASS INDUSTRY. However, a little more of the rubbish clouding Bunker's visionary conceptions of the field of usefulness of the petrographic microscope should be cleared away before the indulgent editors of this estimable journal lock their galleys on this subject. Bunker's portrayal of Elmer might easily lead to the conception that the only workers fit to touch this sacred instrument are a mystical group of white-coated, long-bearded, bespectacled savants occupying an ivory tower from which the common herd of technologists, with a little clay under their finger nails and bits of cullet or frit in their hair, are barred. To use a current phrase, this is the bunk.

In the first place, the Elmers turned loose on the industries today are not totally innocent of the handling and functions of the tool they try to use. A cursory glance at the curricula of most of the leading ceramic schools of today show that nearly all have courses in crystallography, mineralogy and petrography. Further, the deluge of thin section pictures used to illustrate papers dealing with mineral reactions, and serving to stimulate lively intelligent discussions at the meetings of the various divisions of the American Ceramic Society *et al*, would leave little reason to assume that the manipulation of the instrument is any longer an esoteric art, requiring an extended novitiate. The petrographic microscope is any man's servant if he wants to learn to use it. As much as we admire Emic, we believe he is mistaken in taking too literally the copybook maxim that a little knowledge is a dangerous thing for Elmer. Not when accompanied with plenty of enthusiasm by a serious minded beginner. Knowledge continues to grow when catalyzed with this chemical. Also Bunker pictures only a static Elmer and we prefer to think he made a mistake in selecting his type.

Admittedly there is always a fringe of enthusiasts who have not quite caught up with the procession and are still making mistakes but their very interest is only a reflection of the growing attempts to adapt this fascinating tool to the needs of the industry.

And the modern boss! Don't underestimate his judgment. He is no isotropic fool over whose eyes you can pull a Nicols prism to be left forever in total darkness. The chances are he, too, goes to the technical meetings occasionally, and may even take a peek at the Science Service reports. Ten to one, in this day and age of fighting costs, the boss is not laying out four or five hundred dollars for a piece of laboratory equipment without reasonable assurance of getting his money's worth. As for the personnel he chooses to do his laboratory work, a Ph.D. is not a *rara avis* to the boss that he does not know what he is getting when he hires only a B.S. Frequently there is not enough petrographic work to warrant a full time expert. The microscope is just one of many tools which will be used in the study of the boss' problems.

In his personal mental equipment, the boss includes a certain amount of practical knowledge about finance and business law. However, he knows when to consult his banker or attorney and he will expect his technologists, when they confront something unusually tough, likewise to consult with experts such as those in the Universities and Government scientific laboratories.[1] Fortunately, there are a number of such men available for consultation. They have their feet on the ground when it comes to advice concerning both practice and theory in the interpretation of petrographic phenomena.

We finally get around to the really serious question of defining the field of greatest usefulness of the petrographic microscope to the plant technologist. At the outset, it should be kept in mind that this instrument should not be looked upon merely as another tool in analytical microchemistry. First, because this microscope is not capable of precise quantitative work, and secondly, because the exact identification of the phases present is often of less importance than a knowledge of their juxtaposition. In other words, one of the most valuable functions of the petrographic microscope is in the delineation of structures which the eye is incapable of observing. This is to be contrasted with Bunker's chiding of Elmer because he presumably had difficulty in determining exactly which mineral he was seeing when he tried to use the optical properties portrayed so nicely in the diagrams for the system Diopside-Jaedite-Hedenbergite-Acmite.[2] Exact identification is made more difficult by the necessity for speed in solving plant problems and keeping production going. There is also the fact that many commercial products are heterogeneous mixtures rarely at equilibrium and therefore even single crystals are seldom the definite, flawless material which theory suggests.

And now let us dispose of the idea that the Elmers of industry are trying to use the petrographic microscope as the "all seeing eye" which, with one peek "tells all." It will be difficult to find many laboratories possessing petrographic microscopes in the glass, cement, refractories, or even steel industries, which are not also equipped with facilities for making chemical analyses. Some knowledge of the composition of a material is almost essential for the intelligent use of the microscope, and, accordingly, it will be found that chemical analyses frequently furnish very important leads regarding the probable mineral phase present. The average technologist soon discovers that when confronted with certain cryptocrystalline and isotropic phases, or solid solutions and materials with indices of refraction beyond the ordinary liquids, he can turn, if he wishes, for further aid, to X-ray examinations by certain experts well known in the industry.

With the advent of the microsccope in the laboratory there will be a whale of a lot of looking at sections and powders of every product and raw material used in the business. If your Elmer is wise he will increase the usefulness of his microscope by promptly mastering the art of making his own sections. He thereby makes many

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1. Such as the imbibitional investigators described in Paul Emic's dissertation who were always finding Gesundheit associated with quartz instead of with a glass in the system Na_2O-CaO-SiO_2.

2. Even Winchell in his "Elements of Optical Mineralogy" admits these diagrams are based on insufficient evidence and therefore not accurate.

more of them than if he farms them out and has to confront his boss with an invoice for every time he shifts his analyzer. Thus, he builds up, perhaps unconsciously, a great deal of experience in the normal appearance of materials of interest. These experiences serve as reference standards. After awhile in his routine examination, trouble shooting, and interest in competitors' products, he will note variations from the norm, and determine what they mean.

It is well to remember at this stage that the average technologist works with a limited group of raw materials based on their availability, cost, and usefulness in producing the standard products of his industry. Alteration of the raw materials in the production of the finished article also takes place under fairly restricted conditions such as time and temperature of heating. Competitors, likewise, use about the same raw materials, frequently from similar sources of supply, and alter them in nearly the same machines and furnaces. The reaction products to be identified, are confined, accordingly, within certain bounds of probability and it is not always necessary to know as much as the experts to make sufficient identification of the abnormal phases occasionally met.

The microscope has proved to be a really useful tool to note how a new batch ingredient, a change in screen size of batch materials, variations in methods of mixing, molding, firing temperatures, or soaking time, affect such things as homogeneity of the batch, speed and completeness of melting, promotion or retardation of devitrification of vitreous products, miscibility of the liquid components, mechanics of enamel adherence, completeness of inversion of certain minerals under the influence of heat or added mineralizers and the mechanics of bonding of refractory products—to mention only a few general applications.

In addition there are occasional opportunities for high class detective work to determine why the finished product proves inacceptable in appearance, or does not give satisfactory service. This is made difficult because, while the technologist knows the conditions under which his own products are made, he is frequently left uninformed regarding the service conditions to which his products have been exposed. Tracing the failure of refractories from slag action is a case in point.

It has not been intended to leave the idea that the successful use of the petrographic microscope is mere child's play—far from it. However, many a chemist has made an analysis good enough to successfully guide a new process, or dig himself out of trouble, without pretending to be as good as Treadwell, Hillebrand, or our well-known contemporary Lundell—Bunker to the contrary, notwithstanding.

TESTIMONIAL BANQUET TO O. HOMMEL

Nearly 100 friends and business associates attended a banquet in honor of the 70th birthday of Oscar Hommel, president of the O. Hommel Co., at the William Penn Hotel, Pittsburgh, Saturday, December 3, 1938. The entire affair was arranged as a surprise for Mr. Hommel. Mr. A. Leo Weil, Jr., prominent Pittsburgh attorney and lifelong friend, gave the principal address.

A. J. Mittelhauser, Advertising Manager, was in charge of the arrangements. Among the speakers who eulogized the achievement and the active life of Mr. Hommel besides Mr. Weil were: W. A. Hamor, Mellon Institute; Ludwig Hommel, brother of the honored guest; J. E. Rosenberg, Director of Research, O. Hommel Co; E. W. Tillotson, Mellon Institute; B. J. Cassady, Vice President, Pittsburgh Plate Glass Co; John Ogden, publisher of GLASS INDUSTRY. J. F. McCrory, J. F. Ackerman Co., assumed the role of toastmaster.

Numbered among the business associates of Mr. Hommel, in attendance were the following:

A. V. Bleninger, Homer Laughlin China Co.; Joseph Kustch, Ceramic Art Craft Co.; J. W. Hepplewhite, E. M. Knowles China Co.; D. M. Mundt, Porcelier Manufacturing Co.; L. Brown, Hall China Co.; S. L. Lang, Wolfe Brush Co.; L. Messerknecht and C. Messerknecht, Federal Glass Co.; Henry Spore, Homer Laughlin China Co.; Fred May, Kopt Glass Co.; W. J. Frey, Vice-President, Pittsburgh Plate Glass Co.; C. M. Morley, Ketchum-McLeod and Grove, Advertising Agency; Neil Cronin and Kress Cronin, Cronin China Co.; C. M. Elsdon, Pittsburgh Board of Education; W. A. Hamor and E. W. Tillotson, Mellon Institute; Robert Foster, editor Ceramic Industry; J. Parlin Thorley, Professor of Ceramics, Fine Arts Department, University of Pittsburgh; Warren F. Copp, Wheeling Steel Corp.

At a luncheon given by Mr. Oscar Hommel on Saturday, Dec. 3, forty-one employees of the O. Hommel Co., were awarded service emblems. Mr. Hommel gave an inspiring discourse to his employees on this occasion.

The Banquet given in honor of Oscar Hommel, president of O. Hommel Company, to celebrate his seventieth birthday.

THE ADHERENCE OF ALUMINUM TO GLASS*

By DR. BERNARD LONG, F.S.G.T.

Director of the Central Laboratory, St. Gobain Company

Under certain conditions of contact, the surface of glass tenaciously retains aluminum. Thus, if the end of a rod of this metal is moved with strong pressure over a glass surface, an indelible metallic track is left.

This phenomenon of adherence, which has been studied by C. H. Margot and described in two important papers published more than 40 years ago in the "Archives des Sciences Physiques et Naturelles de Geneve," received the following explanation by G. Vogt: "The film of alumina which covers the aluminum scratches the glass, attaches itself to it and holds with it a small amount of the metal."

A second example of very energetic adhesion is furnished by the droplets of fused aluminum which are projected by a spraying pistol on to glass held at a certain temperature.

The following are the stages of the process:

1. After leaving the spray pistol each droplet becomes enclosed in a skin of alumina.
2. The shock of the impact on the glass makes these burst.
3. The fragments of alumina spread around the point of impact and scratch the glass.
4. The metal covers over the scratches and adheres to them on solidifying.

Observed across the face of the glass, the result of applying a drop of aluminum appears as a brilliant patch surrounded by a whitish margin. Viewed from the back it has the appearance simply of an oxidized grain of aluminum.

If the metallizing process be carried on for some time, the droplets projected by the spray pistol blend together and even cover each other. On the glass face there is then a fine mosaic of brilliant patches surrounded by whitish lines; viewed from the other side, this appears as a grained surface of oxidized aluminum.

From the industrial point of view, the process of metallization by friction presents two serious disadvantages, namely: 1, it is slow whatever *modus operandi* is followed, and; 2, it is difficult to obtain a uniform thickness of coating.

The spray process, on the contrary, permits of metallizing glass rapidly and uniformly with a minimum of precautions which are all of a simple nature.

Before passing in review several technical applications which result, it is desirable to indicate that the glass subjected to the metallizing process should, in general, be toughened. The toughening has a double purpose. On the one hand it enables the glass to resist the chilling of the blast from the spray pistol, and on the other, it is effective in protecting the glass against the splintering which tends to occur around the metallized zone when the latter has attained a certain thickness, by reason of the unequal contraction of the aluminum and the underlying glass.

Utilization of the reflecting power of aluminum

The reflecting power of glass covered by aluminum by the spray process is considerable. To fix our ideas, mirrors may be obtained which have a reflecting power for 45° incidence of some 60 per cent of that of a silvered mirror. This figure is a mean value, for individual mirrors vary with the conditions of metallization, such as the temperature of the glass, the nature of the flame used to melt the metal, the state of division of the metal and so on.

Doubtless, by reason of the diffusion produced by the very oxidized regions, the images are somewhat soft, but this defect is largely compensated for by an exceptional resistance to weathering. Thus, convex mirrors for cross roads without any protecting backing have shown no alteration during three years' service.

Among many other applications of the reflecting power it appears of interest to quote the increase in the light-transmitting factor of certain pavement lights intended to be incorporated in reinforced concrete in order to

*Read before the Society of Glass Technology, Sheffield, England, November 10, 1937.

Fig. 1. Circular pavement light.

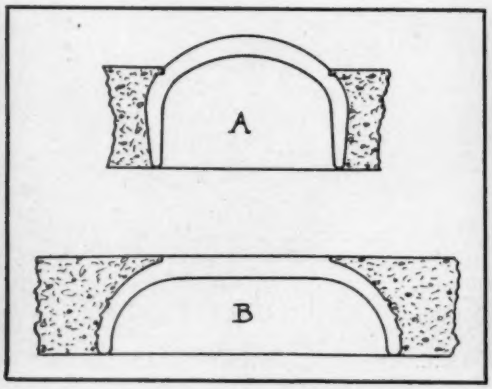


Fig. 2. Round pavement lights in section.

Fig. 3. Circular pavement light.

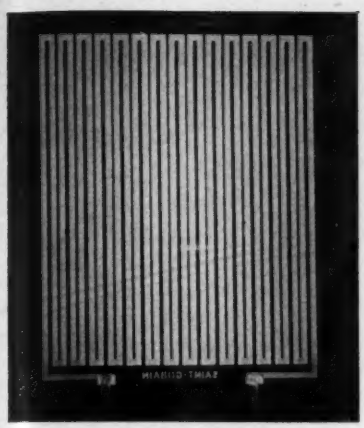


Fig. 4. Hollow glass brick spattered with aluminum.

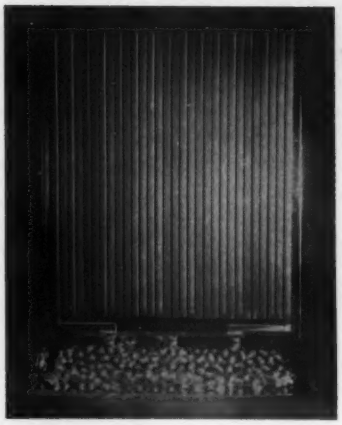


Fig. 5. A method of effecting dark electrical heating.

Fig. 6. Photograph of the metallized face of a glass heater.

render it translucent. A notable fraction of the light which has passed the upper face of a pavement light is dissipated in the concrete by the lateral surface. When the latter is covered with an aluminum coating, the major part of this lost light is reflected to the region to be illuminated.

For round pavement lights represented in section in Fig. 2, the increase in transmitted light due to the metallization of the side surfaces is particularly startling.

The transmission factor for diffused light for the specimen A is 0.40 without, and 0.70 with, metallized side surfaces; and for specimen B is 0.64 without, and 0.76 with. Figs. 1 and 3 are reproductions of photographs of the pavement lights in question.

It is understood that the metallized surface is covered with a special paint to protect the aluminum against the alkaline reaction of the cement before imbedding the pavement light in the latter.

It is known that the reflecting power of aluminum for infra-red radiation is high and in consequence its power of radiating at atmospheric temperature is low. This property has been put to profitable use in reducing the radiation losses from hollow glass bricks intended for use in the construction of outer walls. Before uniting the two half-bricks which together form the hollow brick, a light spattering of aluminum is sprayed on. By this thin sprinkling it is possible to reduce to 60 per cent of its original value the thermal loss from the brick surface, whilst keeping a light transmission factor of approximately 10 per cent for diffuse light.

The hollow brick with aluminum "spattering" (Fig. 4) thus realizes a judicious compromise between light transmission and thermal insulation, so making the ideal material for outer walls.

The Utilization of the Electrical Resistance

In the thin metallic layers obtained by projecting molten aluminum on to toughened glass by means of a metallizing spray pistol, the grains of metal are separated one from the other by fine films of alumina, and it is thus possible to obtain in these layers an electrical resistance considerably higher than that of aluminum in thin sheet form.

In fact, if the thickness of these rough and heterogeneous desposits is taken equal to the mean gravimetric thickness, the measurement of their electrical resistance

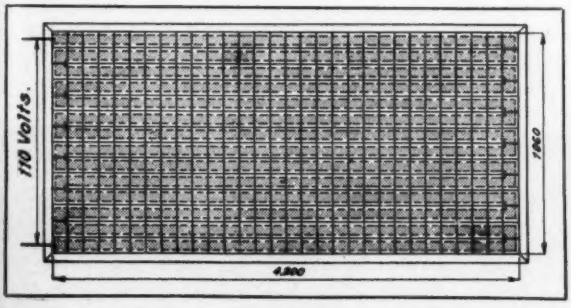


Fig. 7. Arrangement of units for heated glass floors.

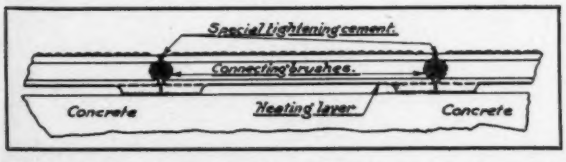
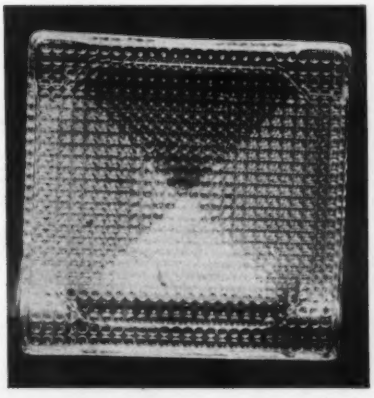
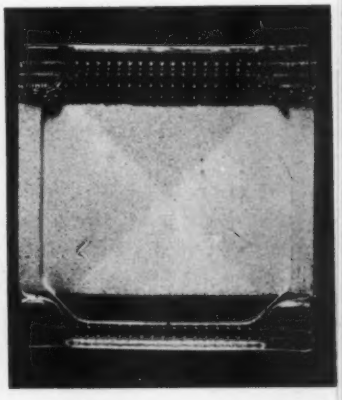


Fig. 8. Schematic view showing the method of laying, joining and connecting heating blocks.





Figs. 9a and 9b. Glass paving blocks with metallized surfaces to enable floor to be heated.

gives evidence of a ratio of resistivities of more than 10.

In these circumstances one may anticipate realizing, for domestic supply voltages of 110 and 220 volts, heating strips on glass, occupying a reasonable area and permitting the dissipation by the Joule effect of a power of 500 to 1,000 watts without the temperature of the glass exceeding 150°.

(*a*) *Glass Radiators*—The apparatus shown in Fig. 5 represents a method of effecting dark electrical heating, by aluminum on glass. The electric energy is here transformed into heat in two vertical panels of "Securit" plate glass 50 x 40 cm., each with a Greek fret of 30 strips, 45 cm. long and 10 mm. wide. Each resistance works under 110 volts.

Fig. 6 is a photograph of a glass heater taken from the side of the metallized face. The two leads may be noted soldered to the extremities of the aluminum strip.

In order that the elements carrying current shall not be accessible to the hand, the two glass plates are placed parallel to each other some millimeters apart, with the metallized surfaces turned inwards, an arrangement that has the advantage of showing up the Greek frets by their brilliant sides.

When once in operation the power dissipated is approximately 1,000 watts, and the temperature on the external faces of the glass does not exceed 130° at the hottest points.

The use of toughened glass plates is made necessary by the method of coating them with metal. This avoids at the same time all scaling of the heating resistance and all danger of fracture of the glass by sudden changes of temperature occasioned by switching the current on and off.

This apparatus can function on either 110 or 220 volts. In the first case the heaters are in parallel, in the other they are in series. By its excellent insulation (resistance on to the glass supported on a glass pedestal), its robustness (toughened glass plates with thick moulded base), its elegance (simple lines and light mounting), the apparatus combines technical efficiency with decorative effect and good taste.

Such glass radiators heat the surrounding atmosphere principally by convection. The radiation from them, however, is far from negligible, though the temperature

Fig. 10. Heated glass floor installed in an office.

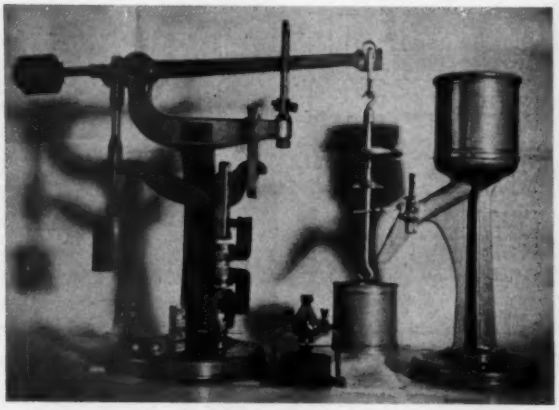
of the glass is generally between 120° and 150°. The heat can be felt on the face if one approaches the glass surface to within a distance of 50 cm., showing that the radiation is relatively large. This property is easily explained if one remembers that the radiating power of glass at the temperatures quoted is nearly that of a black body.

To complete the enumeration of the technical properties of the glass radiators, it must be said that the resistance of the aluminum strips decreases slightly with the time of heating. Thus, for a certain number of strips working in the neighborhood of 110° the decrease in resistance was, after 1,000 hours, 10 per cent, and after 3,000 hours 12 per cent.

(*b*) *Heating Floors*—In the appliances previously described the electrical power dissipated per square decimetre of metallized surface is between 30 and 40 watts, and the temperature attained is in the region of 130°. In coming down to values of a few watts per square decimetre, a temperature of 30° to 40° is attained on the non-metallized face, according to the conditions of heat loss across and at the surface of the glass. Electrical heating at low temperatures and with a very large radiating surface is thus made possible.

Fig. 11. Specimen mounted for test.

Fig. 12. Apparatus for testing adhesion of soldered joints.



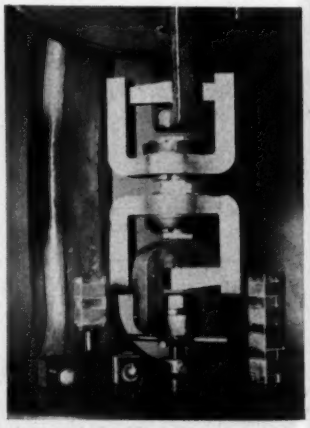


Fig. 13. Gripping device in testing apparatus.

To give an idea of the possibilities of this novel method of heating it will suffice to describe the properties of metallized toughened glass paving stones intended for the construction of heating floors. Figs. 9a and 9b represent views from above and below of a heating glass paving stone 14 x 14 cm. in area and 15 mm. thick in the center. It is metallized on the lower face on a 9 cm. band as well as on the two hemi-cylindrical grooves that abut on the edge. The four "heels" at the corners of the lower face locate the heating resistance some 4 mm. from the base on which the paving block rests.

In order to build up a heating floor consuming a power of 1,200 watts at 110 volts, to give a surface temperature of about 30°, approximately 400 such blocks would be needed, connected in series by means of cylindrical brushes of brass wire. Fig. 8 shows clearly the arrangement, the electrical connections and joints between the individual blocks. A floor of 420 blocks is represented in Fig. 7. The heating resistance which has been lightly dotted in is in the form of a Greek fret with a total length of approximately 55 metres. In order to change direction at right angles, it is evident that blocks with a special type of metallization are necessary. These are easy to design and their execution presents no difficulty.

Once in permanent use (11 amperes at 110 volts) such a floor constitutes a radiating surface of approximately 8 square metres, the temperature of which is in the region of 30° when the desired room temperature is 18° to 20°. Fig. 10 is a photograph of a heating floor in an office.

The Utilization of the Tenacious Adhesion

Aluminum projected by the spray pistol is so tenaciously "encrusted" on the glass that it is quite natural to think of uniting two pieces of toughened glass by metallizing their edges and soldering them together by these metallic deposits.

To carry out this method of assembly, the process which appears to be most practical and certain consists in covering them with a layer of metal which is easily soldered, for example, copper, by means of the spray pistol. In such a case the union of the two pieces is effected without difficulty by means of ordinary lead-tin solder (soft solder).

The determination of the best conditions for assembly can be made by measuring the tenacity of the soldered joints by means of a tensile strength apparatus such as that shown in Figs. 12 and 13. Parallelepipeds of toughened glass 4 cm. thick and of 2 x 2 cm. section are soldered end to end by a central circular region of one square centimeter surface. This operation is carried out in an electric furnace, taking great care to keep the individual segments aligned during the soldering, which is operated under a light pressure.

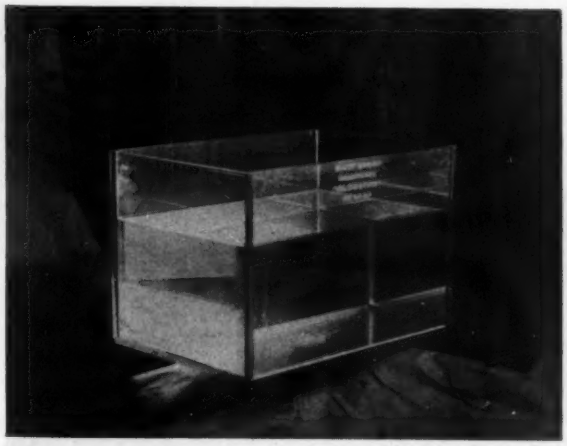


Fig. 14. Tank of glass plates soldered together.

Fig. 15. Built up wall, more than 15 metres high, of hollow glass bricks.

Fig. 11 represents the tensile test piece resulting from the assembly of two such parallelepipeds held at one end in one of the jaws of the apparatus. To avoid any slipping or spalling of the glass by the jaws during the test, the test pieces are metallized on the side surfaces so as to form two large rings.

Some idea of the grip of the solder may be obtained from the fact that the separation of the two halves of the test piece usually calls for a force in excess of 150 kilograms.

Examination of the soldered surfaces after the test shows that in general it is the copper which strips away from the aluminum and not the aluminum from the glass. By improving the interpenetration of the copper and aluminum we may hope to double and perhaps even treble the above figure for the strength of the joint.

The assembly of pieces of toughened glass by means of metal without disturbing the toughened condition has numerous important practical applications. As an example, may be quoted the manufacture of hollow bricks in toughened glass in the form of cells 30 x 30 x 10 cm. which have been used to build up walls more than 15 meters high in the building shown in Feb. 15. These are made by soldering together the edges of two half-bricks of toughened glass. The toughening of their constituent elements confers upon them an extraordinary resistance to the compression to which they are subjected on edge, and it may be permitted perhaps to remark that for this

(*Continued on page* 35)

CONFER ON THIRD INTERNATIONAL GLASS CONGRESS

A group of representative American glass technologists met with Prof. W. E. S. Turner, at the call of Dr. J. C. Hostetter, at the Bureau of Standards in Washington on Dec. 2 for the purpose of discussing participation in the Third International Congress on Glass, to be held in Berlin and Munich, July, 1939.

The program for the Congress, as formed in outline by the International Commission, of which Dr. Hostetter is the American representative, was considered in some detail. It is expected that one, or perhaps two, of the public addresses before the general sessions of the Congress will be assigned to Americans who have recently made outstanding advances in specific fields. Others will present papers and results of researches before sections of the Congress.

The opening sessions of the Congress in Berlin, beginning July 6, will be addressed by two distinguished authorities on general subjects fundamental to glass technology. At Munich, July 11 to 14, various reports and proposals will be considered by groups and sub-groups. The concluding general lectures will be given at Munich, July 15.

The technical work of the Congress, conducted in groups and sub-groups, will cover four broad topics. Under the science and technology of glass there will be papers on the physics of glass, including its constitution and physical properties, with special reference to the subject of mechanical and thermal strength and including all other measurable physical properties. Similarly, the chemistry of glass as related to analytical methods, the study of chemical resistance and phase relationships and the like, come under this general division. Other subdivisions are glass batches and glass melting, the flow of glass, and defects; furnace technology brings in heating problems including the application of electricity, the construction and operation of furnaces and their efficiency. Finally, the manipulation of molten glass, especially mechanical working, will be considered in detail.

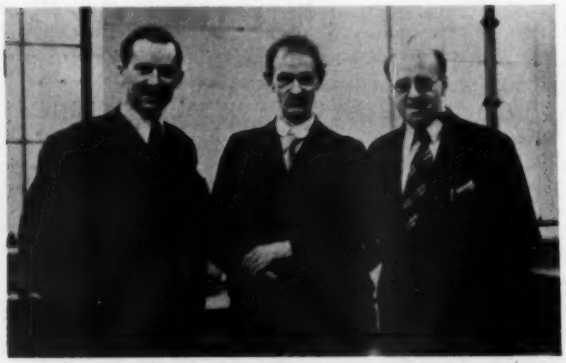
The second general division of the program takes up art in glass, covering such items as glass in architecture, decorations and design, and application, and the history of glass production.

The third general division covers social measures, health and accident protection. Here such matters as the conditions of work, the regulation of working time, protection against specific dangers and poisons, and protection against excessive dust, heat and mechanical injuries will be considered.

The final division of the program is labeled Glass Technological Literature; and in this division ideas will be exchanged on publication, on standards and standardization, dictionaries and bibliographies. Final division of the Congress into appropriate groups and sub-groups will be made after it is definitely known what contributions will be received in the various fields.

Committee C-14, A.S.T.M., of which Dr. G. W. Morey is chairman, made progress reports to the group, and discussed with Professor Turner the test methods being developed in cooperation with foreign technologists. It will be recalled that the Germans have undertaken work on chemical durability, the English, on thermal endurance, and the Americans, on tensile strength. Critical comment is expected from the other groups as to the methods proposed, but when criticisms have been satisfactorily answered, said Prof. Turner, it is expected that each method will be internationally accepted. He made this remark as the view of the International Commission, of which he is president. Prof. Turner remarked also that methods for estimating these properties would each yield consistent values in the hands of those experienced in its use, while agreement between values obtained by different methods, using in particular specimens of different form, could scarcely be expected.

Dr. Lyman J. Briggs, Director of the National Bureau of Standards, briefly addressed the meeting, welcoming the glass men to the Bureau, where, he said, glass has become one of the important materials for study, because of its increasing utility in many supplies purchased by the Federal Government, and especially because of the continual research and development work required on optical glass for the military and naval forces. Mr. A. N. Finn, of the Bureau, and Dr. Morey, of the Geophysical Laboratory, were informal hosts to the gathering, arranging for luncheon at the Wardman Hotel, and dinner at the Cosmos Club. Mr. V. V. Kelsey attended in his official capacity as president of the American Ceramic Society.



Professor W. E. S. Turner of the University of Sheffield who sailed for England last month after a tour of the American glass making centers. This picture was taken at Pennsylvania State College, while visiting Dr. Taylor and Dr. Weyl.

• Latest entry in the glass production field is heavensent. A United Press dispatch from Tampa, Florida, reports that a bolt of lightning struck a tree, ran down the tree and jumped from the tree roots to an underground telephone cable. Along the underground path, the heat fused sand into an irregular tube of glass.

• In "The School of Tomorrow" at the New York World's Fair 1939, visitors will be able to watch the actual functioning of pre-school elementary classes, polarized glass screens making it possible for the children to be observed without their knowing it.

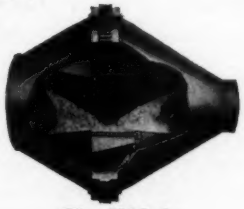
EQUIPMENT AND SUPPLIES

V-SHAPED BLADES FOR GLASS BATCH MIXERS

The Smith batch mixer equipped with V-blades.

The T. L. Smith Co., Milwaukee, Wis., report that their dust-sealed tilting drum type of glass batch mixer, illustrated above, is now regularly equipped with converging V-shaped blades. The materials are kept in constant motion, moving from the ends to the center of the drum.

Vertical cascading and unnecessary agitation are avoided by substituting a less violent rolling action, largely independent of the speed of the drum. It is claimed the mixed match will not segregate during discharge because mixing continues during the discharge operation.



The V-blades.

The new type of V-blades are mounted clear of the drum shell. Thus there are no pockets or corners in which materials can collect. When the drum is tilted, the entire batch is discharged with no ingredients remaining in the drum. The T. L. Smith Co. points out that this is particularly advantageous where batch formulas are frequently changed.

IMPORTS KRYOLITH

The Pennsylvania Salt Manufacturing Co., 1000 Widener Building, Philadelphia, Pa., has advised THE GLASS INDUSTRY that they are the sole importers of kryolith into North America, and has recently published a pamphlet, called "Kryolith," which describes the properties and applications of this double salt of sodium fluoride and aluminum fluoride for the manufacture of glass, recommending that it be used as an opacifier and fluxing agent.

TAYLOR APPOINTS

Chas. Taylor Sons Co., Cincinnati, has appointed the International Allied Engineering Corporation to be its exclusive sales representatives in Argentina, Brazil, Chile, Peru and Uruguay. Senior executive and general manager of International Allied is F. M. Hartford, former vice-president of the Horrop Ceramic Co. of Columbus, Ohio, and one of the organizers of the Allied Engineering Corporation. Both of these organizations specialize in the design and construction of tunnel kilns, complete plants engaged in the manufacture of ceramic products, drying and fining problems, glaze compositions, etc.

Mr. Hartford is located at the main office of International Allied Engineering in Buenos Aires, Argentina. Branch offices are maintained in Rio de Janeiro, Sao Paulo, Brazil, and in Santiago de Chile.

BULLETINS RECEIVED

American Monorail Co., 13107 Athens Ave., Cleveland. A 48-page booklet shows construction details of monorail track and tractors, including pneumatic-tire drive. Many illustrations of equipment installed in a great variety of industrial plants, including glass, are also given.

Hauck Manufacturing Co., 125 Tenth St., Brooklyn, N. Y. Loose-leaf folder includes three catalogues of gas-burning equipment. No. 802 covers low-pressure air-induction mixers; No. 803 illustrates and describes high-pressure gas inspirators; No. 804 shows features of "Retain-A-Flame" burner nozzles.

The Bristol Company, Waterbury, Conn. A 36-page booklet illustrates and describes the wide-strip pyrometer, showing construction details, operation features, applications and accessories. Also available is a 28-page bulletin, No. 515, on the Metameter system of telemetering, including construction and installation details for pressure, water level, temperature, flow, mechanical motion and electrical units.

Ideal Commutator Dresser Co., Sycamore, Ill. Illustrated folder describes a variety of useful equipment including variable-speed transmission, electric soldering tools, eltctric etchers, markers, wire strippers, insulation tester, and other small specialties.

M. B. Skinner Co., South Bend, Ind. New 32-page catalog features a "leak-loss" chart, together with illustrated descriptions of nine different styles of pipe-repair clamps.

Thwing-Albert Instrument Co., 3339 Lancaster Ave., Philadelphia. Bulletin M-382 lists the company's complete line of instruments for measuring and controlling temperatures. Fully illustrated are both indicating and recording types.

Flexrock Co., 800 North Delaware Ave., Philadelphia, has issued a new booklet entitled "Flexrock Non-Slip Wax." This describes a non-slip wax made with pure carnauba wax with other ingredients to provide the non-slip feature.

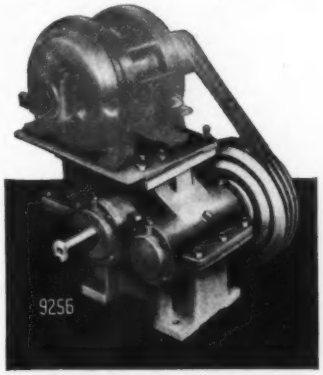
Chain Belt Co., Milwaukee. Bulletin No. 332 is a well-illustrated 6-page folder covering the design and use of Rex Apron Conveyors. Tables of dimensions and capacities are included.

WILL BUY

The Chemical Service Corporation, 235 Fourth Ave., New York, advises that now that the inventory season is at hand, it is prepared to purchase surplus stocks of finished and raw materials of all kinds, as well as machinery and equipment.

SACO SPEED REDUCERS

Under the trade-name SACO, a line of constant-ratio speed reducers has recently been placed on the market by Stephens-Adamson Mfg. Co., Aurora, Ill. These power units include high and low speed shafts and gears in a cast housing, on top of which is arranged a mounting pad for a standard motor. The motor drives the high-speed gear shaft through a V-belt, the motor support being adjustable to accommodate various sizes of sheaves and permit convenient replacement if a change in output speed is required. Gear shafts are mounted in ball bearings and the helical, cut-steel gears operate in a bath of oil. Output speeds range from 13.2 to 172 r.p.m. with standard motors and the bearing construction for the low-speed shafts permits an over-hung load on the shaft extension. The manufacturer states that the transmission efficiency of these reducers ranges from 89 to 93 per cent, depending on the radio of reduction. Bulletin No. 7638 gives complete engineering data.



CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

Base Materials

		Carlots	Less Carlots
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	43.00	46.00
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Borax ($Na_2B_4O_710H_2O$)	lb.	....	....
Granulated	In bags, lb.	.0215	.027-.0295
Powdered	In bags, lb.	.024	.0295-.032
Boric acid (H_3BO_3) granulated	In bags, lb.	.048	.054-.0565
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Cryolite (Na_3AlF_6) Natural Greenland (Kryolith)	lb.	.0875	.0925
Synthetic (Artificial)	lb.	.085	.0875
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	30.00	....
In bags	ton	31.60	38.00-40.60
Kryolith (see Cryolite)			
Lead Oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0725	....
In 5 Ton lots	lb.	....	.0775
Less than 5 Tons	lb.	....	.0825
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	11.50
Burnt (CaO) ground, in bulk	ton	7.00	....
Burnt, ground, in paper sacks	ton	9.00	10.00
Burnt, ground, in 180 lb. drums	Per drum	1.60	1.70
Kiln Dried ($CaCO_3$) 10x30 mesh	ton	1.75	....
Kiln Dried ($CaCO_3$) 16x120 mesh	ton	1.75	....
Nepheline Syenite, f. o. b. shipping point	ton	13.00-14.00	....
Potassium carbonate—			
Calcined (K_2CO_3) 96-98%	lb.	.065	.0675
Hydrated 80-85%	lb.	.055	.0575
Salt cake, glassmakers (Na_2SO_4)	ton	15.00	25.00
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	.95	....
In barrels	Per 100 lb.	1.35	....
In bags	Per 100 lb.	1.10	....
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls. 95% and 97%	Per 100 lb.	....	2.50-2.90
Bulk	Per 100 lb.	1.35	....
200 lb. bags		1.415	1.44
100 lb. bags		1.45	1.475

Special Materials

		Carlots	Less Carlots
Aluminum hydrate (Al $(OH)_3$)	lb.	.029	.03½
Aluminum oxide (Al_2O_3)	lb.	.04	.07
Antimony oxide (Sb_2O_3)	lb.	.11½	.12¼
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03	.03½
Barium nitrate ($Ba(NO_3)_2$)	lb.	....	.07¾
Pyrophyllite, (20% Al_2O_3)	ton	9.00	12.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.04-.04¼	.04½-.05
Tin Oxide (SnO_2) in bbls.	lb.	....	.50
Titanium Oxide (ceramic grade)			
In bags	lb.	.13¼	.13½-.14
In barrels	lb.	.13½	.13¾-.14¼
Zinc Oxide (ZnO)			
American process, Bags	lb.	.06½	.06½
White Seal, 150 lb. bbls.	lb.	.08¾	.09
Green Seal bags	lb.	.08	.08¼
Domestic White Seal bags	lb.	.08½	.08¾
Red Seal, bags	lb.	.07½	.07¾
Zircon			
Refined Granular (Milled .01-.02c higher)		.06½	.07-.08
Commercial, Gran. (Milled .02¼-.02½ higher)		.024	.029

Coloring Materials

		Carlots	Less Carlots
Barium selenite ($BaSeO_3$)	lb.	....	1.40-1.60
(Commercial, 25% Selenium)	lb.	....	.85
Cadmium sulphide (CdS)	lb.	....	.80-.85
Chromite (99% through 200 mesh)	lb.	35.50	40.00
Cerium hydrate—			
100 lb. drums and 600 lb. barrels	lb.	....	.60
Chrome Oxide Green, 400 lb. bbls.	lb.	....	.22-.26
Cobalt oxide (Co_2O_3)			
In bbls. 350 lbs. or more,	lb.	....	1.67
Less than 350 lbs.,	lb.	....	1.77
Copper oxide—			
Red (Cu_2O)	lb.	....	.185
Black (CuO)	lb.	....	.16-.17
Black prepared	lb.	....	.22
Iron Oxide—			
Red (Fe_2O_3)	lb.	....	.0425-.09
Black (Fe_3O_4)	lb.	.04½	.09
Iron Chromate	lb.	....	.035-.05
Lead Chromate ($PbCrO_4$) in bbls.	lb.	....	.145
Manganese, Black Oxide			
In Paper bags	ton	47.50	50.50-54.50
In Burlap bags	ton	49.25	52.25-57.25
In Casks	ton	51.50	54.50-59.50
Neodymium oxalate, 50 lb. drums	lb.	....	3.50
Nickel oxide (Ni_2O_3), black	lb.	....	.35-.40
Nickel monoxide (NiO), green	lb.	....	.35-.37
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	.08¾	.09-.09¼
Powdered	lb.	....	.09½-.09¾
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	....	.27
Powder blue	lb.	....	.2075-.2125
Rare earth hydrate—			
100 lb. drums	lb.	....	.35
325 lb. barrels	lb.	....	.30
Selenium (Se) In 100 lb. lots	lb.	....	1.75
In lesser quantities	lb.	....	1.85
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06¾	.07-.07¼
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	.08½	.08½-.08⅝
Sodium selenite (Na_2SeO_3)	lb.	....	1.50-1.65.
Sodium uranate (Na_2UO_4) Orange	lb.	....	1.75-1.80
Yellow	lb.	....	1.75-1.80
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	....	2.65-2.75
Yellow orange	lb.	....	1.75-1.80

Polishing Materials

		Carlots	Less Carlots
Emery, Turkish	lb.	.063	.07
Pumice Stone,			
American Ground Italian FFF, FF, F	lb.	....	.03
0, 0½, ½, 1.	lb.	....	.03¼
Putty Powder	lb.	....	.38-.42
Rotten Stone, (Domestic)	lb.	....	.02
Rouge, Red	lb.	....	.14
Black	lb.	....	.16

ADHERENCE OF ALUMINUM TO GLASS

(*Continued from page* 31)

reason they are very much superior to non-toughened bricks of similar type.

Another good example of this method of assembly is the rectangular tank shown in Fig. 14, intended to contain liquids of a not too corrosive nature, or to protect fragile objects.

Finally, if one may anticipate future achievements, we may draw attention to the vast possibilities opened up for glass furniture made without those metallic fittings which always add to the weight and often spoil the aesthetic effect.

To conclude this survey of the application of the tenacity of the union between aluminum and glass, one should perhaps not omit to mention the fact, quite evident from what has been said already, that the assembly by soldering may be equally well applied to join together pieces of toughened glass and pieces of metal so that glass may be built into the metal structure where this is advisable.

NICOLS CORRECTS OPTICAL GLASS ARTICLE

The Editor of THE GLASS INDUSTRY,

Dear Sir:

"On page 465 of the December number of your publication, in Dr. Oscar Knapp's article on Optical Glass, I find this statement (para. 1): 'Should such a disc serve as an astronomical mirror, its price would be about $220,000.'

"Should not this sentence read something like this, 'Should such a disc serve as half of an astronomical objective doublet, its price would be about $220,000.' All objectives are necessarily at least doublets of different optical glasses, to minimize chromatic aberration. Astronomical *mirrors* are not made of optical glass, since the light does not penetrate their glass, but of a special low-expansion Pyrex glass silvered or aluminized on the *top* of the precision surface. The Pyrex glass serves only as a mechanical support for the metallic reflecting surface.

(Signed) *Lowell W. Nicols*"

NEW BUILDING MATERIALS RESEARCH AT MELLON INSTITUTE

Dr. Edward R. Weidlein, Director, Mellon Institute, Pittsburgh, has announced the establishment of an Industrial Fellowship in that institution by the United States Gypsum Co., of Chicago, Ill. This Fellowship will conduct fundamental research on various products manufactured by the donor company, with the objective of developing new processes and technics which will have broad application in the field of building materials. This investigational work will augment the regular research activities carried on by the donor. Dr. H. E. Simpson, who has been appointed to the incumbency of the Fellowship, has been a member of Mellon Institute since 1936 on the staff of the Multiple Fellowship on glass technology.

MANUFACTURES PRECISION TUBING

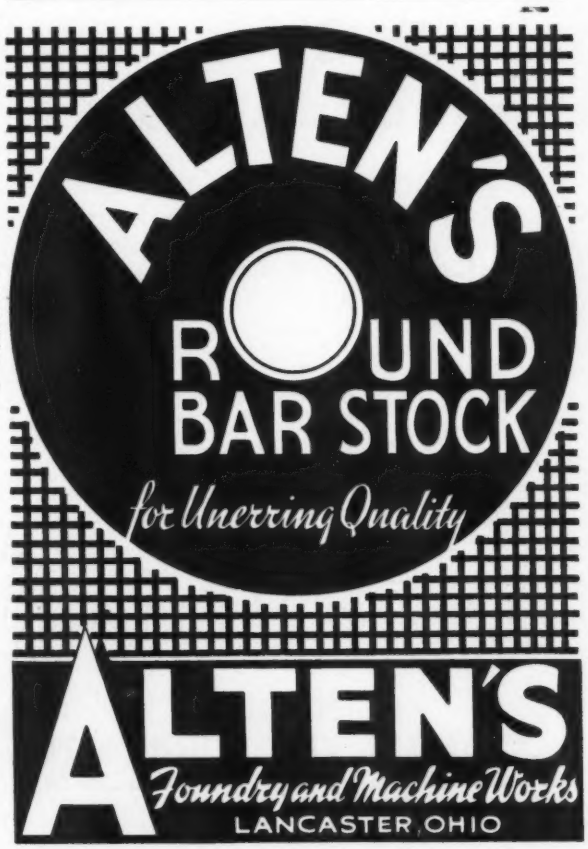
The Fischer & Porter Co., Germantown, Pa., report that they have developed a process which enables them to manufacture glass tubing to precise and interchangeable internal dimensions. Their process has been used largely for tubes having diameters as small as ½ mm. and as large as 4.2 in. On the large tubes the company works to tolerances of 0.001 in. and by the time they get down to a ½ in. diameter tube, can reduce the tolerance to 0.0002 in.

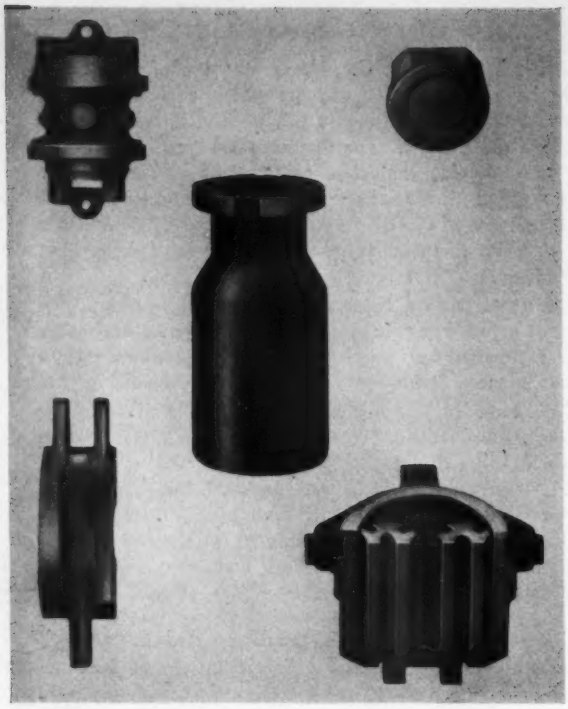
To quote from a letter from Kermit K. Fischer, "We do not actually manufacture glass from sand and other raw materials, but purchase glass tubing and make it more accurate by means of our forming process.

"We have applied our abilities regarding glass tubing to the manufacture of rotameter type flow meters which are widely used in the chemical industry. However, we are now branching out to viscosimeter tubes, haemocytometer tubes and are gradually finding other uses for precision-bore tubing. We are able to produce precision-bore glass in cylindrical, conical, square and octagonal shapes in the sizes and tolerances given above."

• "How to Operate Under the Wage and Hour Law" is a new book by Alexander Feller and Jacob E. Hurwitz, prominent counsellors on labor law.

WALL COATING OF COLORED GLASS TILES. Expert wishes to find glass works or wholesale dealers interested in the above. Best references. Hugo, Neumann, Plzen, Nádrazni 34, Czechoslovakia.





Gunite Bottle Moulds Reduce Production Costs

The use of GUNITE bottle moulds will reduce your production costs, for GUNITE is of just the right hardness to facilitate easy machining and of just the right density to assure a metal which will take a brilliant polish. It also reduces chipping at exposed quarters to a minimum during machining.

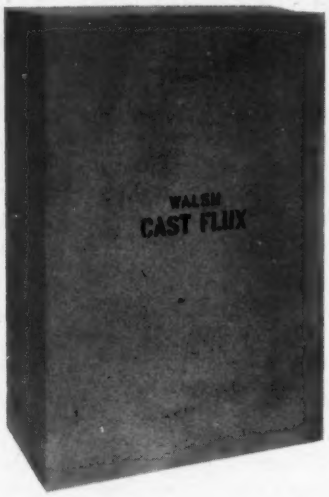
To these advantages of using GUNITE, add the following plus value properties:—excellent thermo-conductivity, resistance to heat fatigue, freedom from foundry defects, and unusually long life.

These properties of GUNITE, which make for economy in production and increased sales of the finished product, are the result of fifteen years of research and five years of testing under actual operating conditions.

Write for our booklet which presents factual data and descriptions of the entire line of GUNITE castings.

GUNITE FOUNDRIES CORPORATION
ROCKFORD ILLINOIS
Established 1854

WALSH CAST-FLUX



The Vacuum-cast flux block of superior quality.

Walsh Cast-Flux blocks are machine-trued to exact size and shape after burning.

THEY LAST LONGER

The excellent results obtained in numerous tanks melting various types of glass has definitely established the efficiency and economy of Walsh Cast-Flux blocks.

Walsh Cast-Flux has a dense, uniform structure; it is burned at higher temperatures, is thoroughly bonded and possesses a low coefficient of expansion.

Walsh Cast-Flux blocks meet the most rigid requirements for tanks operating at higher temperatures . . . they insure greater tonnage, higher quality glass, freedom from defects, longer life and maximum economy.

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Manufacturers of Refractories for the glass industry for over 50 years

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BINNEY

MIN-OX
RESISTS SCALE

"SEMPER FIDELIS"

MIN-OX moulds, because they are made of scientifically developed alloys especially suited to the needs of the glass industry, will give you greater fidelity to design in intricate mould work.

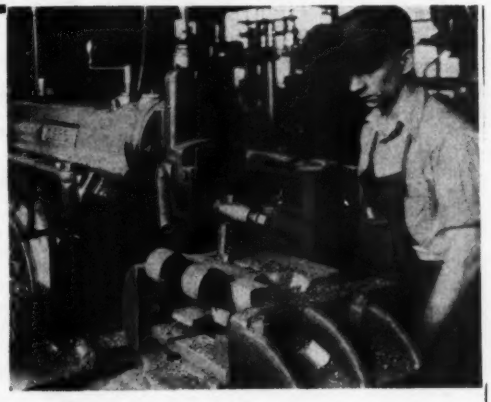
Moreover, MIN-OX moulds will actually cut your production costs by practically eliminating fire-finishing—by reducing spoiled ware to an absolute minimum—and by giving longer life.

Further, they will increase your sales by imparting brilliancy to glassware.

Semper fidelis—always faithful—might well be the motto not only of the glassware produced by MIN-OX moulds, but also of the conscientious service which we have always tried to render the glass industry.

THE BINNEY CASTINGS COMPANY
TOLEDO, OHIO
originators of alloys for glass molds

BINNEY



Machining the face of a section for a bottle mould.

• The production of moulds for glass manufacturing is a task in which high grade workmanship is combined with first-class equipment.

THE TOLEDO MOULD COMPANY
1920 CLINTON STREET
Toledo, Ohio, U.S.A.

SOLVAY

TRADE MARK REG. U. S. PAT. OFF.

PRODUCTS

Already a BEST SELLER *and why—*

Because—this new form of Potassium Carbonate meets a definite need of the glass industry.

Because—it is a domestic product, made in the U. S. A., manufactured by SOLVAY and measuring up in every way to the superior standards of the SOLVAY line.

Because—it is *easy* to use and assures new *economies* in glass manufacturing.

Because—it is *not* a powder, but a definite granulation of the *same* density as SOLVAY Dustless Dense Soda Ash.

SOLVAY DUSTLESS CALCINED
98-100%

POTASSIUM CARBONATE

Also

GRANULAR HYDRATED 83-85%

•

GROUND CAUSTIC POTASH

•

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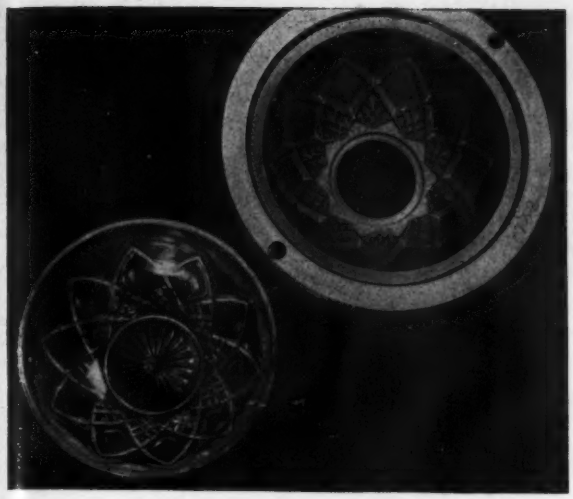
CHEMISTS AND CONSULTING ENGINEERS
FOR THE GLASS INDUSTRY
LANCASTER, OHIO U. S. A.

Laclede Christy
SAINT LOUIS

Our files contain the records of 3,380 tests on clays and minerals. We designed and built the first and largest test furnace exclusively for testing glass house refractories. We have maintained a Mellon Institute Fellowship for 20 years . . . all for the benefit of Glass Manufacturers.

V 6R3



Gortons save time on fancy molds

The tool room can save a great deal of time on glass molds with repetitive patterns by putting them on a Gorton Duplicator. Take the glass dish shown above with its mold. Only enough of the pattern to serve as a model of the design need be cut by tooling out. The whole mold can then be reproduced from this partial model by placing it in an indexing fixture on the Duplicator. This mold was cut on an 8-½-D Duplicator in 26 hours complete. The glass dish is 8″ diam. and 3″ deep. Gorton single flute cutters run at high speeds left a smooth finish remarkably free from tool marks.

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YOU MAKE PROFITS

. . . . whenever you use fuel in our patented tanks. We will be glad to give you estimates of fuel costs utilizing Forter-Teichmann furnaces as compared with your present operating equipment.

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Vertical Sand Damper

A safety-first valve
for your producer gas mains

A recent shipment of TECO-MAYER'S Vertical Sand Dampers for use in a large plate glass factory's modern producer plant.

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NO PLATE WARPAGE — NO METAL TO METAL SEAL
TWO MINUTE OPERATION — SIMPLE TO OPERATE

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